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# USSR Report

SPACE

No. 23



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## MANNED MISSION HIGHLIGHTS

### ZAYTSEV COMMENTS ON MODULAR ORBITAL STATIONS

Tallinn SOVETSKAYA ESTONIYA in Russian 12 Apr 83 p 4

[Article by Yu. Zaytsev, department chief at the USSR Academy of Sciences Institute of Space Research: "Laboratories in Space"; SOVETSKAYA ESTONIYA exclusive]

[Excerpt] What will be the path of future development for orbital stations? It is possible that in time orbital stations will become larger, but how much larger remains an open question. In any event, at the present stage in the development of cosmonautics large stations are hardly expedient. The larger the station the greater the time spent setting it up; and meanwhile technology is being developed rapidly, new design decisions are appearing, and new technical ideas and work become apparent. The possibility is not excluded that a large station might become obsolete even before it is put into orbit. Today, therefore, it is more advantageous to use relatively small, relatively cheap, and at the same time improved stations that offer an opportunity for varying the scientific program and concentrating attention separately on the most important scientific directions.

At the same time, some directions in cosmonautics, and in space technology, astronomy and other sciences, have already reached such a high level of research that it is no longer possible to move further ahead merely by mounting one or two instruments on board. The need is arising to develop sets of equipment. In essence it is a question of a specialized laboratory and perhaps even a unique production shop. It is virtually impossible to install several of these laboratories on a single station, but there is no need for this. A more optimal variant is available: docking interchangeable specialized modules with a station. When the research program is changed some modules can be undocked and other new ones attached. Modules can be standardized. Each will have its own engine and will be placed in orbit by an individual carrier rocket.

The most expedient geometric shape for such a module is a sphere or cylinder. Modules of this shape have the least weight for given useful volume. They are convenient for assembly and fit well into the contours of the carrier rocket. Assembled from cylindrical or spherical modules, a station could have various configurations. It is these kind of modular stations that are evidently the stations of the immediate future.

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## COMMENTARY ON 'SOYUZ T-8' RENDEZVOUS FAILURE

Moscow KRASNAYA ZVEZDA in Russian 23 Apr 83 p 3

[Article by colonel engineer M. Rebrov, special correspondent: "Command: 'Reentry'"]

[Text] Flight Control Center--With the appearance of the orbital stations the path to the "Salyut's" has been taken many times. Nevertheless, this now regular operation is not so simple as may be imagined. The "Soyuz T-8" started its pursuit run when the "Salyut-7" was in the eastern part of the country. The vehicle went into orbit and the station was already moving toward Australia. It had to "find" it. There was to be no wandering about along the roads of space but progression along a strictly defined route. With a correction, of course. For ahead lay a road about 740,000 kilometers long.

Even in the first orbits the "Okeany" started to check out the radiotechnical systems in the vehicle, and then, the first maneuvers. The vehicle moved into a higher orbit. According to data from the ballistics flight support group its parameters matched the calculated parameters. The movement within movement continued.

I deliberately called the flight of the vehicle and the station movement within movement. Our enormous world is built in such a way that the Sun moves along its galactic orbit at a velocity of 250 kilometers a second. Without even noticing it we are moving at a dizzy speed across interstellar space, hurtling along a galactic orbit 30 times faster than a space rocket! We are hurtling along but we do not sense this movement. We do not sense it because this for us "crazy" speed as we rotate about the galactic center is insignificant from the standpoint of distances in space.

A comparison. If we liken our Earth to a grain of sand, the Sun will be the size of a small apple. On this scale, how far away is the nearest star to us, Alpha Centauri? If we place our grain of sand--the Earth--at one of a long table and the apple--the Sun--at the other end, then Alpha Centauri will be somewhere near Kaluga. And the center of the galaxy around which we rotate along with the Sun? It will be much further away than the Moon. It will be more than 1.5 million kilometers distant. These are the scales of space!

And it is not surprising that even as we race through galactic space at 250 kilometers a second we do not see any star movement and nothing indicates our movement. But among the enormous multitude of "frozen" stars, there is one very small one that is travelling about the sky. And the "Okeany" had to find it.

The night passed. The data have changed on the electronic display screen in the control center. Orange lights flash the date: "21 April." At 0900 hours Moscow time the "Okeany" started their next day. One after another the little explanatory pictures on the side screens change: "Scheme for vehicle and station"; "Docking scheme." Everything on them seems extremely simple. In the actual flight this apparent simplicity was hemmed about with the terse work of the crew and the duty shift at the control center.

The "Okeany" made their final orbit correction at the end of the first day of the flight. The engine was burned twice; it was a two-thrust maneuver. Everything went according to the book, and now the vehicle and the station were a little over 10 kilometers apart. The distance shortened. A steady flow of information was being passed between those working in orbit and the center operators.

"'Zarya' this is 'Okean-1.' I can see the lighted point" reported Vladimir Titov.

The approach and docking stage is brief. But it is still a test of patience. In the complex interaction of radiotechnical facilities, the vehicle's electronic brain and the actions of the crew themselves, everything worked with jeweled precision. But this did not take the pressure off the duty operators. Right at the start of the flight, deviations from the predicted rendezvous conditions had been noted. Ballistics had had to alter the scheme for the maneuvers.

The distance between the vehicle and station was closing with each passing minute. No, each passing second! A few hundred meters separated the "Soyuz T-8" and the "Salyut-7."

On Earth and in space people were putting every effort into their work. Just a little, it seemed, and the "Soyuz T-8" would dock with the "Salyut-7." But the control center remained true to its own rule: the most important thing is safety. The crew were ordered to break off further maneuvers. And no matter how exasperating it was for the "Okeany," the control center decided to cancel the docking.

On 22 April "Zarya" transmitted to the crew the computed data for the landing. The reentry was, is, and evidently will be for a long time to come, one of the most crucial stages in any space program.

Accurate orientation, the burn of the braking engine, separation of the compartments, the entry into the dense layers of the atmosphere.... All this requires coordination, precision, and a strict sequence for carrying out the numerous complicated operations. They all took place without incident. At 1728 hours and 42 seconds the reentry vehicle of the "Soyuz T-8" made a soft landing on Earth.

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## 'SALYUT-7' PASSES ONE YEAR IN ORBIT MARK

Moscow KRASNAYA ZVEZDA in Russian 19 Apr 83 p 3

[Article by V. Blagov, USSR State Prize laureate, entitled "Salyut-7: Still on Station"]

[Text] Flight Control Center--Today marks exactly 1 year since the multifunction scientific laboratory, the orbital station "Salyut-7" was put into orbit. During this time since 19 April 1982 it has circled the Earth 5,755 times and flown more than 240 million kilometers. This substantially exceeds the mean distance from the Earth to the Sun, which is about 149.5 million kilometers. About 4,000 communications session have been held; more than 1 trillion bits of scientific and service data have been passed via the telemetry channels; and about 1.5 million data bits in the form of commands and so-called control commands have been transmitted to the station.

At one period two stations were operating in orbit at the same time, namely the "Salyut-7" and the "Salyut-6--Cosmos-1267" complex. Their orbital planes were at an angle of about 90 degrees. When the "Salyut-6" station was above the western part of the Soviet Union, the "Salyut-7" had only just entered the zone of radio contact with the ground measuring points located in the east of the country. The flight control center worked both stations at the same time.

On 14 May 1982 the "Salyut-7" was visited by its first expedition made up of Anatoliy Berezovoy and Valentin Lebedev who worked in space for 211 days. During this time the station was visited by two crews: a Soviet-French crew (Vladimir Dzhanibekov, Aleksandr Ivanchenkov and Jean-Loup Chretien), and a Soviet crew that included a woman (Leonid Popov, Aleksandr Serebrov and Svetlana Savitskaya). Four "Progress" freighters (nos 13, 14, 15 and 16) delivered replacement equipment, new scientific instruments and technologic installations to the "Salyut-7" and took up new food, water, fuel and supplies of other expendable materials.

During the course of the flight an extensive scientific program has been carried out. It would be difficult to list all the experiments, studies, goal-oriented observations and tests of technical equipment that have been conducted aboard the "Salyut-7." During the course of this flight, semiindustrial space installations have been put into operation for the first time. Using

the "Korund" equipment the cosmonauts have conducted experiments to obtain semiconductor materials possessing properties difficult to obtain in terrestrial conditions. These kinds of studies have also opened up the road for organizing the output of industrial batches of semiconductor monocrystals in weightless conditions.

The feasibility of and a method for obtaining a number of biologically pure materials using electrophoresis have also been demonstrated. About 300 experiments have been conducted, including the "Meduza," "Gel'," "Magnitogravistat," "Tavriya," "Koordinatsiya," "Ekhografiya," "Malakhit" and "Duga" experiments. Work has been done with the RT-4M X-ray telescope and the SKR-02M spectrometer, the "Yelena" gamma telescope and PCN equipment, and the "Piramig." The "Iskra-2" and "Iskra-3" satellites, designed for amateur radio enthusiasts, have also been launched from the "Salyut-7."

A total of 20,000 pictures of the Earth's surface have been obtained using the station's equipment. A large number of pictures and observations were made using hand-held movie and still cameras and spectrometry equipment. A whole range of experiments was conducted that have already been applied in science and practice.

One of the main features in the operation of the "Salyut-7" relates both to the crew and the personnel at the control center; this is the use of new orientation and control methods for scientific equipment using the onboard "Delta" system which includes a minicomputer.

I would particularly like to talk about the duration of the work by the main expedition. The time spent in flight by the "El'brusy" from the moment of launch to landing was 211 days and 9 hours, or about 7 months. (Note that this is long enough for a flight to Venus and back, not counting time spent on the planet). The results from medical and biological studies done by the crew and scientists are of great importance for the further development of manned flights.

The basic medical finding obtained during this flight is that increasing the time humans spend in space compared with flights of shorter duration did not lead to the appearance of any qualitatively new shifts in the cosmonauts' bodies.

The "Salyut-7" station--now docked with the "Cosmos-1443"--continues on station in automatic mode. Aboard, everything has been prepared to receive the next expeditions. This was all done before A. Berezovoy and V. Lebedev left their "stellar home." Preparations took about 3 days. All movable equipment was secured in its place behind the compartment panels. Detailed information on stowage work was transmitted to Earth. One copy of this information was left aboard the station, together with the traditional letter to the new proprietors.

There is more. The unified engine installation was fueled. Exhaust fans and air regenerators were serviced and new filters installed. The television

camera was aimed at the entry airlock, awaiting the appearance of the new crew that will have to start up the next space navigation and continue the work of the "Salyut-7."

Two traditional Russian dolls, "Ivan" and "Mariya," made by craftsmen from Semenov city in Gorkiy Oblast, are waiting aboard the station for the arrival of the new settlers "responsible" for it.

Operating in automatic mode, the "Salyut-7"--"Cosmos-1443" complex continues to transmit scientific and technical information to Earth.

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## RYUMIN INTERVIEWED ON 'SALYUT' EXPERIMENTS

Kiev PRAVDA UKRAINY in Russian 24 Feb 83 p 3

[Interview with V.V. Ryumin, Twice Hero of the Soviet Union, pilot-cosmonaut of the USSR, by PRAVDA UKRAINY correspondent V. Petrenko: "Space Orbits and Earth Orbits"; data and place not specified]

[Text] [Question] During two long-duration space missions you carried out many different kinds of materials science technological studies aboard the orbital station, including work on the "Isparitel'" installation developed in Kiev. How do you assess the scientific and practical significance of these experiments and the prospects for work on space technologies?

[Answer] First of all I would like to say that I am happy with the present meeting with our good partners in this interesting joint work--the scientists and specialists of the Institute of Electric Welding imeni Ye.O. Paton who developed the "Isparitel'" and of the Ukrainian SSR Academy of Sciences Institute of Electrodynamics, who provided the compact and reliable power source for this installation. The Kiev scientists not only developed promising technology and equipment to realize the technology, but also provided much help for us in starting up the installations and during the course of experiments when Vsevolod Lapchinskiy and Aleksandr Zagrebel'nyy and their colleagues at the Paton institute remained for a long period at the Space Flight Center, consulting with our crew on particular fine points of the experiments.

And before the second long-duration mission Leonid Popov and I familiarized ourselves in detail with the installation and trained while still on Earth. Our knowledge and experience was added to that of the development engineers, and in space we succeeded in dealing with 200 samples. Much new information was obtained both for science and practical work.

[Question] The crews of the "Salyut's" always give much attention to studies connected with growing various plants aboard the station. In your opinion, what role can "space plant growing" play in future flights?

[Answer] My comrades and I succeeded in growing peas, onions, wheat and other plants while in orbit. The plants also included exotic orchids from Kiev and the grass arabidopsis [vneshne nevzrachnaya travka arabidopsis], which was a surprising discovery for the biologists. For a long time it was not

possible to complete a whole cycle of plant growth--from seed to seed--in space, and with arabidopsis this was finally accomplished. Popov and I finally got this plant to flower for the first time, and Berezovoy and Lebdev also obtained arabidopsis seed.

In the meanwhile the "green friends" of man grown by cosmonauts in the "Malakhita," "Vazon," "Oazis," "Biogravistat" and other onboard installations are not only the subject of comprehensive study but also--and I stress this--a not unimportant psychological factor exerting a positive effect on the emotions of the cosmonauts.

[Question] During the course of work aboard the "Salyut-7" the "Tavriya" biotechnological experiment was performed. What were the results?

[Answer] I think that this experiment, prepared by the Simferopol people at the Crimea Medical Institute jointly with scientists from the Moscow Higher Technical School imeni N.E. Bauman and other collectives, was one of the most interesting and promising. Under weightless conditions we succeeded in separating various biologically active substances in the "Tavriya" installation with great efficiency, obtaining components whose purity was tens and sometimes hundreds of times greater than those obtained in terrestrial conditions.

The subjects used in these experiments aboard the "Salyut-7" included bone marrow and spleen cells, albumin--one of the blood proteins--the antiviral preparation hemagglutinin, and amino acids and enzymes essential in medicine, agriculture and other sectors. The results give hope for and make it possible to look optimistically to the future; particularly if it is possible to develop equipment capable of processing substances in large amounts in space stations.

[Question] Valeriy Viktorovich, you worked aboard the "Salyut-6" as an astrophysicist, metallurgist, geologist, repair man, gardner, photographer, oceanographer and researcher of the Earth's natural resources--the list is endless! Which of these space professions is closest to your heart?

[Answer] On the station I derived satisfaction from all kinds of planned work (except, of course, the medical experiments, but, naturally, they were always on a volunteer basis). In this we were helped by an understanding that the results of the work done were being impatiently awaited on Earth by the specialists in various branches of science and technology, and the most varied sectors of the national economy. And since by profession I am an engineer I like very much to work with equipment; and so solving engineering problems during the flight was the thing I liked best.

[Question] Which is more difficult" to fly in space yourself or to direct the flights of others? And how does the very rich experience of cosmonauts in "Earth orbits" [that is, on the ground--ed] help flight directors?

[Answer] My own space experience helps me a lot. And it was not happenstance that my predecessor Aleksey Yeliseyev was also an experienced cosmonaut who had completed three missions. From my viewpoint, to make decisions on Earth

and give commands is even more difficult: it sometimes seems that it would be easier to carry out a particular operation yourself rather than assign it to someone else.

[Question] The recent flight by Svetlana Savitskaya has inspired definite hopes in the hearts of the fair sex. What is your opinion of the prospects for further participation by women in space missions?

[Answer] I think that in the long term we shall witness the participation of women in crews sent up to orbital stations. But in order for medicine to solve this far from simple question in the best way, we shall need a checkout lasting not just a week but a long time.

[Question] If, as we suppose, you are asked to go into space again, would you agree?

[Answer] It is unlikely that I shall go into space again for at least the next few years: there is much work to be done at the Space Flight Center. But since the physicians still do not have anything against me, I still have a dream of flying again one day. The only thing: I would like it to be not a short flight, but a long one, a month, or even three or four.

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## INTERVIEW WITH COSMONAUT SAVITSKAYA

Moscow NEDELYA in Russian No 2, 10-16 Jan 83 p 13

[Interview with cosmonaut Svetlana Yevgen'yevna Savitskaya by Marina Pavlova; date and place not specified]

[Excerpts] Today our guest is Hero of the Soviet Union Svetlana Yevgen'yevna Savitskaya, pilot-cosmonaut of the USSR, member of the Komsomol Central Committee. We might add that she is an honored master of sports, an absolute world champion in advanced flying, and has gained 18 world flying records.

[Question] Svetlana Yevgen'yevna, what professionals would be useful and advisable to participate in space flights? For example, is a journalist needed aboard a space station?

[Answer] I think that first of all physicians and psychologists would be "appropriate": they would see much of interest if they spent time as cosmonaut observers. As for the journalist... Well, you know, it is better to show space flights in movie theaters, say, rather than just write about them. As they say, one picture is worth a thousand words... It would be more useful to have a cameraman who would do nothing but shoot film: the footage he would get!

[Question] Of course. And in general, what is your attitude toward journalists?

[Answer] Variable. When writing about me, some of them engage in heavy conjectures, especially about "why I began to fly." According to them it turns out that I "dreamed about it" and "raved about it." But of course, with some dreams, if there is no precisely defined goal, they come to nothing.

[Question] Doubtless you encountered some obstacles on the way to becoming a cosmonaut?

[Answer] I would not say that they were all personal. In principle, you know, many used to think, and many still do, that aviation and cosmonautics are not women's work. Sometimes I encountered the following attitude: as long as everything is going all right, no one says anything. But if there

is suddenly a small working trouble, then the talk starts: "This is what you get when a woman is involved" (even though, possibly, the man saying this has made some blunder, and possibly a more serious one). And so you have to be especially careful, otherwise your mistake is held against women in general.

[Question] Would you like to be a member of an all-women crew?

[Answer] (smiling) Yes. Work would be interesting....

[Question] I suppose that in your mixed crew some psychological problems arose. For example?

[Answer] The main problem has been to convince everyone that there were no kinds of problems at all with our crew.

[Question] How many times can a cosmonaut go into space?

[Answer] I would be able to repeat the same flight program, and even a different one after training. The more so since from the medical viewpoint there are no restrictions. And in general, the more you fly the better you fly. This makes it possible to go into the flight in the best what we call "operational" form... On the other hand, there was a gap of almost 10 years between Valentin Lebedev's two flights and this was in no way a hindrance. So things can be different.

[Question] Tell us something about your backup.

[Answer] She completed the full program of flight training and coped very well.

[Question] How do you like space food?

[Answer] We ate the same food twice--once for a week during training, and on the flight itself. At that time we specially "selected from the allowance" in the dining room and the "space" canned and sublimated food. Our comrades bantered with us and advised us (and offered their assistance) to go to the store. But we got by very well without this and drank space tea and ate very well and quite adequately from the medical viewpoint.

[Question] Did you dream while in space?

[Answer] I rarely dream even on Earth, and in space I did not dream at all. Sleep there was excellent.

[Question] Now, after the flight, do you think it is possible to live outside the Earth?

[Answer] I think that only specially trained people can work in space, and this is understandable. But they should also know that after they have carried out their program, perhaps a program lasting many years, they will definitely return home to Earth.

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## BLAGOV RECOUNTS 'SOYUZ-33' DOCKING FAILURE

Moscow KRASNAYA ZVEZDA in Russian 2 Apr 83 p 4

[Article by V. Blagov, USSR State Prize laureate: "One Day After Launch"]

[Text] Following publication of the notes by pilot-cosmonaut of the USSR, Hero of the Soviet Union colonel V. Lazarev with which we initiated our new column "In the Orbit of Courage," many readers' letters arrived at the editorial office asking for more details on the work of cosmonauts in complex flight situations. A. Matveyev from Novosibirsk, B. Milevskiy from Krasnodar, K. Puzakov from Odessa, A. Khitrov from Yelgava, Ye. Kaprova from SHChelkovo and others in particular asked for this.

Viktor Dmitriyevich Blagov, deputy flight controller, talks about one such situation and the work of the crew and specialists at the flight control center.

### Docking Is Canceled.

Yuriy Gagarin once said: "We are all testers, each of us doing something for the first time. A new vehicle, new equipment, new instruments, a new research program... Each person conducts his own 'test', does something for the first time..." We first encountered this "something" during the flight of "Soyuz-33" in the spring of 1979.

Testing sometimes brings grief as well as joy. This is natural. However, in either event, people learn more. And K.E. Tsiolkovskiy, who foresaw so much of what we are now doing, was right when he said that people who learn from history "should be courageous and not halt their activities because they fail! It is necessary to find the reasons for the failure and eliminate them."

The reliability of space technology is built in even during planning. Through the efforts of many collectives--designers, testers, cosmonauts, flight control specialists--its index is brought to a high level. But random events--the logic of development in everything new--cannot be excluded.

This memorable flight started at 2034 hours Moscow time on 10 April 1979. Vehicle commander Nikolay Rukavishnikov and Bulgarian space researcher and cosmonaut Georgiy Ivanov brought their "Soyuz-33" up for docking with the "Salyut-6"--"Soyuz-32" orbital complex. V. Lyakhov and V. Ryumin were waiting for them on the station. It was the fourth mission of the "Intercosmos" program.

One day had elapsed. During this time all tests had been completed and three maneuvers for distant closure carried out; the vehicle's onboard systems were working normally. The most crucial moment on which the success of the entire planned work depended, was approaching. "Soyuz-33" and "Salyut-6" were about 16 kilometers apart.

The red light on the screen in the control center signifying the "Soyuz-33" was coming closer and closer to the blue light--the "Salyut-6." V. Staroverov's shift was on duty. The flight controller A. Yeliseyev was also there. I was with those controlling the "Salyut-6."

"Locked on." The transmission came from space.

The "Igla" radio measurement system was in display mode, providing the crew and us (via the telemetry channels) with data on range and rate of approach. The distance was closing rapidly.

The "Saturny" reported "9 kilometers, ACU on." ACU is easily decoded: it means "approach control unit. This automatic device is used on this part of the flight. Its electronic brain analyzes the actual parameters for the relative movement of the vehicle and the station, compares them with the parameters held in computer memory, and gives commands for acceleration, braking and compensation for lateral drift.

"Distance 4 kilometers" the approach control specialist reported on the PA system.

"Visual sighting of station," the "Saturny" reported. "Target located at 4 grids [kletki] above, exactly on center."

"Target on screen," V. Lyakhov reported from the "Salyut-6."

Flight control gave permission to switch in the approach-correcting engine. The last 1,000 meters after many thousands of kilometers of space flight. And during these minutes, when it seemed that the most difficult part was now behind, a hitch occurred in the normal approach process: telemetry showed that the "Igla" and the engine were switching off at random. The duty shift immediately drew attention to this abnormality. Nikolay Rukavishnikov also noticed the deviation from normal conditions. They established that the "Igla" had randomly switched itself off 3 seconds into the burn of the approach-control engine instead of the computed 6 seconds.

The tension that usually reigns during this stage of the operation, increased significantly. Each hitch during the approach can lead to an abort of the docking and so a decision would have to be made extremely quickly. Specialists

began to work on the various possibilities. It was necessary to answer a whole range of questions to explain what had happened: "A random malfunction in the 'Igla' system?" "A false signal in the electrical circuits?" "A malfunction in the engine itself?"

The third possibility seemed the most unlikely. No similar "surprises" had ever occurred before in this engine during flight. And in ground tests when it had been "run up to full power" nothing of this sort had happened. More than 2,000 engine runs, all without incident, all very precise. And now on the "Soyuz-33" the first six burns without incident; and now the seventh....

The main thing was to establish the real reason. Everything had to be carefully checked. How much time would this take? an hour? five? 10? perhaps an entire day? more than a day? We did not have the time. A decision had to be made just in minutes, using the information to hand.

The specialists pondered. Time flew by. They were all of one mind, one desire: to complete the operation properly, not to "axe," as we say, the entire program. It was easy to call off the docking, but would it be possible to repeat it if it turned out that we had been to hasty in retreating?

The point of minimum distance had been passed. From that second on, the distance between the vehicles would increase. But rendezvous was still possible. So, another attempt?

The command was transmitted: "'Saturny,' switch on 'Igla' and approach control unit. Clear for approach-control engine from approach-control unit."

The engine was switched on for the acceleration and immediately switched itself off. This meant that the malfunction was not random. There was some hidden fault. It had to be found!

"Saturny." The silence was broken by Earth. "Discontinue rendezvous mode. We shall report our decision on the next orbit."

"Should we take off our pressure suits?" we heard from orbit.

"If we alter our decision you will be able to don them," came the evasive answer from the ground. "There will be time..."

Rukavishnikov clarified this. "The engine fired sluggishly. We felt some vibration."

They called the "Protony." Ryumin answered: "Everything normal on the station. We saw the 'Saturny's' engine burn. We noticed a lateral glow from the power compartment."

Could it be the engine after all?

Ninety minutes went by in a flash. The next communication session was approaching. There is an inflexible rule in the control center: if there

is a chance for success but it is accompanied by even the smallest risk, the operation must be aborted. The crew requested permission to repeat the operation. Flight controller Aleksey Stanislavovich Yeliseyev was firm. The signal was transmitted.

"Remove your pressure suits. Crew to rest. You are not clear to switch on approach-correction engine..."

Yeliseyev spoke quietly. But the special intonation in the voice showed the pressure he was under.

"We must think out the burn, 'Saturny.' Everything will be OK, but we have to think it out. Meanwhile, sleep." He ended the conversation.

"Roger," Rukavishnikov replied.

He was also calm, but he could not hide his disappointment. The crew understood quite well that docking with the station had been canceled and that they would have to return to Earth. How would this be? At that time no one could answer this.

#### An Anxious Night.

It was past 0200 hours. Specialists at the center were analyzing the situation. More precise information was needed and it had to be carefully processed. On the desk lay telemetry readouts, graphs, circuit diagrams. The records of conversations with the "Saturny" and "Protony" were being analyzed.

Everyone was alarmed by the report of the lateral glow. Telemetry confirmed that the main engine had switched itself off by [actuation of] the pressure sensor in the combustion chamber. The malfunction was a serious one. In this kind of situation it was no longer possible to use the main engine. There was a reserve--the backup thruster. It was not suitable for rendezvous because it was designed for only a single burn--at full thrust for the reentry. And if the glow--the jet of very hot gases coming from the main engine--had actually hit the side it could also have damaged the reserve engine. This could not be excluded. That night all possible versions of the reentry and what to do next were considered. Time passed quickly. Very quickly! That night was a long one and a short one simultaneously. 'We knew that the crew were not sleeping, that up there in orbit they also had a very good idea of the complexity of the situation. Afterwards, Nikolay Rukavishnikov was to say:

"I thought of the engine immediately but I did not want to exacerbate the situation. On Earth, they were going through the same thing as us... I thought about it all night. As commander, I was responsible not only for myself and the vehicle but also for Georgiy. I had to consider all possibilities and be ready for any question from the ground, ready for any command they could give me..."

"Georgiy interrupted my thoughts. 'Commander,' he said, 'should we not fortify ourselves?' We had brought gifts along for the 'Salyut.' A special collection

put together by our Bulgarian comrades. 'Open up the gift package,' I replied. 'You're sure?' asked Georgiy. 'I'm sure' I answered.

"We opened the handsome red box tied with a multicolored ribbon and fortified ourselves. I had very little, Georgiy took a good drink.

"'Get some sleep,' I said to Georgiy. 'We must get a good rest. Tomorrow will be a difficult day.' To myself I thought: 'Equipment is equipment. And each space flight is still a test flight. We shall carry out that test tomorrow, Cosmonauts' Day...'

"I could not sleep. I recalled the assemblies of the engine installation. The combustion chambers of the main and backup engines are jammed in a small space close to each other with a mass of fuel lines and cables. The main engine was damaged, that was clear. And what if the backup was too? There is still another--the docking engine. We had to calculate what could be done with the remains of the fuel in the docking engine. For that extreme case..."

At the altitudes at which the "Soyuz" vehicles usually fly the density of the surrounding atmosphere creates a certain resistance and a vehicle could descend from orbit even without a braking engine. But it would take 10 days for this. Food and water reserves were calculated for 4 or 5 days, and oxygen even less.

A short digression. The reader probably knows the name Martin (Keydin) the American test pilot and later government consultant on space research matters. This man is well known as the author of a science fiction novel entitled ("Trapped in Orbit"). I do not intend to tell you all about the engrossing events in this tale of dramatic adventure in space. I shall cite just one monologue delivered by the person "lost in orbit."

"Perhaps I can still break out! Several hours before my inevitable fate..."

The hero of the book, (Pruett) was carefully looking at a Russian vehicle flying alongside. He swung about and started to approach it...

"'I shall embrace this fellow like a brother after a long separation, if it will just drag me a little toward its bulk. And I shall be pleased to set out for home with him the long way round!'

"A sense of deliverance swept over (Pruett). He realized that he could come back to life...."

But whereas (Keydin) was thinking about an emergency situation resulting from an engine malfunction, life itself had prepared the "Saturny" for a great trial.

The "Saturny" Return.

And so, the possibilities. If the backup engine was functioning the crew could return to Earth in the stipulated region. And if the backup engine

was not functioning it was possible to reduce velocity with the low-thrust engines used for orientation and docking, and to land the vehicle on USSR territory. Since the time that these engines operate continuously is limited, in order to achieve the required braking thrust they would have to be switched on several times. And this would lead to a large spread for possible landing points and would complicate the work of the search and recovery service. This possibility was also unfavorable because of the fuel situation.

In principle, another "exotic" possibility was available: bring the station and the vehicle close together using the "Salyut" engine down to 1 kilometer, and then switch on the "Soyuz-33" docking engine, dock, go aboard the station, and then send a reserve vehicle for the crew to return in. This possibility required complex ballistic computations that required time. Meanwhile, the station and the vehicle were separating at the rate of 100 kilometers an hour.

And in any event, what about the main engine? And another docking attempt? We all wanted very much to "bring" the vehicle to the station and start the planned work. However, switching on the main engine could result in a fire in the compartment and damage the backup. The control center made its decision: on the following day reentry would be attempted with the backup engine. In the event that the control cables for its steering nozzle had been damaged, a method had been worked out for combined startup of the docking engine and the steering nozzles of the backup engine.

In the computer planning group they worked without pause, checking the reentry figures for each main and reserve orbit.

And again, more possibilities. If the backup engine burned for 188 seconds, there was no problem. If, however, the time was less, the "Soyuz-33" would enter the dense layers of the atmosphere after several orbits and land in an uncalculated region. In this event, provision was made for an additional burn of the engine manually. If the engine burned for less than 90 seconds, the vehicle would remain in orbit. Then.... Then there would be new possibilities.

The morning of 12 April dawned. The "Saturny" were to communicate 2 hours before noon. At 1000 hours Rukavishnikov was calling "Zarya."

"This is 'Saturn.' How do you read me?"

"What is your status?" Yeliseyev started the conversation.

"Normal," Nikolay replied. "We are ready for work."

"Happy holiday," said Yeliseyev. "We are going to transmit reentry data."

"Ready to receive."

"Not immediately. Wait a while. What are you doing?"

"Having breakfast. Georgiy got hungry while we were resting."

Of course, that was for the holiday.

"How about the engine." Nikolay broke into my thoughts. "We have thought of some possibilities. Shall we discuss them?"

Discussion showed that the cosmonauts in orbit had also thought through every detail. Many of their evaluations matched ours. Good old Kolya! He is really good with equipment. And the main thing is he is calm; he even raised our spirits:

"Don't worry men. Everything will be normal..."

Whether or not that would be so we were unable to say at that time. And obviously the "Saturny" were also aware of this. It seemed to me that Nikolay had been correct in his suggestion that the reserve engine might have been damaged. But it had to be used at full thrust. The main thing was to get into the atmosphere... And the commander knew quite well that the crew had to prepare themselves, be as alert as possible, not to make a mistake in giving commands. We felt that he also had confidence in Georgiy. Georgiy was also calm, joking, imperturbable, finding useful work for himself.... Rukavishnikov could not sleep that night either.

Communications with the vehicle continued.

"If the engine burns for less than 90 seconds, don't do anything precipitate. We'll decide everything together," Yeliseyev sent.

"We understand the situation. We'll look after the engine."

The final calculated orbit. The vehicle entered the zone of contact with the "Borovichi" seaborne measuring complex. At 1846 hours and 49 seconds the backup engine was switched on.

Later, Nikolay Rukavishnikov related:

"And so we started. 'Engine burn at 150 seconds, 160, 170.' Georgiy was doing the count. Then he said: 'Commander, the burn ends at 188 seconds.' And that second came and went, but the engine did not switch off. What was going on? If it burned for much longer reentry into the Earth's atmosphere would be very steep. This is dangerous. Could we switch it off manually? And suddenly it was no longer operating at full thrust; were we still in orbit? Seconds for reflection. Switch off the engine manually, bring the vehicle into ballistic reentry mode. This seems the best thing to do. I let the engine burn for 25 seconds over the set time and then I push the switchoff button. Silence. No sound over the radio either. We switch on all our communications facilities. 'Engine burned for 123 seconds. Moving in ballistic reentry.' No answer. We repeat the report over and over. Finally the control center responds. There, it seems, they all sighed with relief..."

"Twenty minutes had elapsed since the moment the engine was switched off. Full weightless conditions still exist in the cabin. We wait impatiently

for the vehicle to enter the atmosphere. Another 5 minutes, it seems like a year. Then the dust starts to settle. The thread of the "weightlessness sensor" that Georgiy had designed quivered and began to stretch. We'd made it!"

The overload that the crew experienced was of the order of 8-10 G. In a normal reentry it is no more than 3-4 G. At 1935 hours the "Soyuz-33" reentry vehicle made a soft landing on Earth.

And there you have everything about this flight. We worked according to a backup version. In the very complex situation all groups at the control center acted precisely and coolly. The skill of the cosmonauts and the calm of the crew inspired us with confidence. We gained very valuable experience of operating in a very complex situation.

One thing remained to be solved: what to do about the "Soyuz-32" whose engine was from the same batch as the one on the "Soyuz-33"? A new vehicle--the "Soyuz-34"--was prepared for launch. Its engine was tested taking into account what had happened. It was launched unmanned and delivered additional freight into orbit, including equipment developed by Soviet and Bulgarian specialists. It was on this vehicle that the "Proton" expedition--V. Lyakhov and V. Ryumin--returned to Earth after completion of their long mission. The equipment operated without incident.

"Somewhere I heard a turn of phrase used by a schoolchild, and children are always more direct and trusting than adults. The lad said it to his friend after meeting the cosmonauts: 'Just think, they flew into space! Two days, and you're a hero already!' My fine boy, our entire life up to that point had been for those 2 days!"

These lines were written by Vladislav Volkov, cosmonaut tester. It would be difficult to add another word.

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## STAR CITY ASTRONAUT TRAINING CENTER

Moscow ZVEZDNYY GORODOK (NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA "KOSMONAVTIKA, ASTRONOMIYA") in Russian No 8, Aug 81 (signed to press 24 Jul 81) pp 27-37, 46-52

[Chapters 4 and 6 from booklet "Star City" in the "Astronautics and Astronomy" series of "What's New in Life, Science and Technology", by Ernest Anisimovich Vaskevich, Izdatel'stvo "Znaniye", 28,440 copies, 64 pages]

### [Excerpts] Astronaut Training Facilities

In training personnel for space flights, various hardware is used for both general and professional astronaut training. Let us first discuss the facilities for general training for space flight which prepares astronauts to endure the unfavorable factors that affect the human organism under the conditions of space flight.

There are several of these facilities since the effect of each of these factors has to be brought out. For example, a centrifuge is used to bring out the effect of G-forces on the human organism, and hydrolaboratories and "flying laboratories" are used to bring out the reaction of the human organism under the conditions of weightlessness. Extravehicular activity, using a space pressure suit and the capability of working in emergency situations (sharp drops in pressure, seal failure, etc.) require the astronaut to condition his organism in advance in the pressure chamber, thermal vacuum chamber, hydrolaboratory and on the stands of the life-support systems.

Almost everyone now knows what a centrifuge is, after seeing one in action many times in movies or on television. This rotating device is used to simulate the G-forces encountered by pilots during flights in aircraft, and by astronauts when a spaceship leaves orbit for reentry to earth. Mounted on one centrifuge shoulder, which can reach some 20 meters in length, is a cabin for housing an astronaut. The cabin is either rigidly attached or mounted in a Cardan device; in the latter case, it can have several degrees of freedom while rotating in different directions.

Rotation of the centrifuge shoulder with the cabin attached to it must increase both smoothly and rather rapidly. The same requirements are also imposed on stopping rotation of the centrifuge. All information on the human being tested and the operation of the apparatus in the cabin is sent to control consoles, where physicians and instructors closely monitor the astronaut's state of health, the correctness of performance of the tests given him, and the reliability of operation of the apparatus and mechanisms of the centrifuge.

The centrifuge is a good facility for assessing the capability of man to withstand G-forces and for conditioning the human organism for them. It is widely used to select and condition flight personnel in aviation and differs from the one used in training astronauts only in design. Momentary (for fractions of a second) G-forces under the conditions of actual flight may reach ten units; therefore, the centrifuge is manufactured to produce G-forces in several tens of units.

Pressure chambers are also used in both aviation and astronautics. A pressure chamber is a stationary, hermetically sealed room in which the barometric pressure can be artificially varied; in thermal altitude chambers, the temperature can be varied as well. The chambers used to test and condition astronauts are larger than those used in aviation. As a rule, they are also sectional chambers in which a mockup of a spaceship or compartments of an orbiting station can be placed. Standard equipment, actual hatches, latches, etc., are used in practicing operations for extravehicular activity.

There are also a number of other differences from "aviation" pressure chambers, in which a pilot is "raised" to altitude in so-called plateaus, with brief interruptions in attaining the specified "altitude." Also, a pilot is not in a space pressure suit like the astronauts are during conditioning. Astronauts wear space suits in the pressure chambers when practicing elements of the flight mission for extravehicular activity. In these chambers, astronauts develop the habit of working outside the station: making an outside inspection, and performing operations on assembly and disassembly of equipment on the outside surface of space vehicles. Finally, the reliability of the space suits themselves is checked in these tests.

Similar operations are performed by astronauts in the hydrolaboratory, a sturdy structure based on a tank. A mockup of an orbiting station is installed on the tank bottom which can either be lowered to full depth or raised. Astronauts in special pressure suits resembling divers practice in the water the elements of walking into space through hatches, perform exercises on assembly and disassembly of equipment on the outside surface of the station, refine the aspects of interaction during extravehicular activity, etc.

In the hydrolaboratory building, there are posts for controlling and observing the astronauts undergoing training. All information on the state of health of the astronauts is sent to the posts, communication with them is maintained, and the air supply, status of the pressure suits, depth of the operation and other parameters are monitored. Visual observations and motion pictures are made through special portholes. For insurance, there are scuba divers in aqualung suits next to the astronauts in the water during training: If necessary, they can help the astronauts at any time.

The hydrolaboratory is a relatively new facility in training Soviet astronauts. Combining the conditioning in the pressure chamber with that in the hydro-medium allows astronauts to acquire rather strong and stable habits of working in pressure suits. The pressure chamber simulates the conditions of the space vacuum, and the hydrolaboratory, that of weightlessness. The fact is that when a body is immersed in water, at a certain depth it acquires the properties of zero buoyancy; the state of the astronauts immersed in water is rather close to the real condition of weightlessness, and their actions and movements under these conditions is similar to those in real space flight.

Conditions of weightlessness can also be obtained on an aircraft when it executes a certain flight condition (zooms). But this weightlessness is no simulation as in a hydro-medium, but reality with all the characteristic properties of weightlessness that appear in space flight. Therefore, training in "flying laboratories" is part of the astronaut training program now to familiarize them with these space flight conditions that are unusual on earth. In the process, the astronauts perform operations such as putting on and taking off their space suits, stabilizing their body in space, etc.

However, the limited time (up to 30 seconds) of the weightlessness condition on an aircraft, flight dependence on weather conditions and time of day have compelled scientists and designers to look for other ways of obtaining the conditions of weightlessness on earth. Various principles and devices have been suggested and tested: in deep shafts with a free-falling lift, rotating tanks filled with liquid, multistage suspensions of a person to obtain a support-free position, sloping planes and others. For one reason or another, they all did not work out.

Only water tanks or hydro-pools are usefully different from the listed devices. By immersing a body in water, we create rather complete simulation of weightlessness, i.e. we attain a neutral (equilibrium) position of an object or person at a certain depth. And this condition is exactly what is needed for practicing many operations astronauts perform in real space flight. Admittedly, in contrast to the weightlessness produced in an aircraft, earth's usual force of gravity continues to affect the structure of the apparatus and the person in the hydrolaboratory.

In astronaut training, especially in the training for the early space flights when the ship's crew consisted of one, anechoic chambers have played a prominent role. These chambers are special rooms with soundproof walls. They were used to condition astronauts for psychological stability of the organism. They are now used in selecting astronauts; they can be used in determining psychological compatibility of two or more crew members and to prepare the crew for very long flights.

General training also includes physical conditioning which, just as flight and medico-biological training, is conducted throughout the entire period of training astronauts for flights.

We have discussed the facilities for general training for space flights. For professional training of astronauts, there are complex and specialized simulators. A complex simulator includes a mockup of the cabin in the space ship or station with actual interiors, standard apparatus, systems and units, and work stations for crew members where the astronauts perform their duties in flight. For example, for the Soyuz simulator, the work stations are the re-entry vehicle and the orbiting module. During training exercises, the astronauts are in the simulator cabins a long time; therefore, the simulator includes a system for air conditioning and controlling the supply of air in the cabin and space suits (if the astronauts have to be in space suits in accordance with the mission).

The complex trainer includes various space flight simulators (electromechanical, electronic, television and others). The electromechanical starry sky simulator, for example, is a dark globe; applied to its surface in the appropriate scale are the constellations made of metallic balls with different diameters. The moon and

planets move through the starry sky with the aid of special Cardan devices. All the stars, planets and the moon move to match their actual movement across the horizon as a function of the location, attitude and movement of the "space ship" (the simulator cabin) in orbit.

A simulator of the external space environment can be made in the form of a globe of the earth's surface or endless film strips portraying the earth's surface. The globe rotates or the film moves in accordance with the daily movement of earth and the space ship. The sections of the earth's surface over which the space ship is "passing" at any given time are transmitted to the simulator cabin (to an optical sight and to a television screen) by using special optical and television devices. From the movement ("course") of the earth in the optical sight, the astronauts can visually determine the ship's orientation with respect to earth rather precisely.

The docking simulator is also a complex electromechanical device. The space vehicle (ship or station), with which the crew has to dock, is a precise copy of the actual object with all the lines, exterior elements, signal lights, antennas, etc. The model has several degrees of freedom, turns and moves forward in accordance with the signals sent by the astronauts from the stationary simulator cabin. Powerful lights simulate the sun, illuminating the model from a particular direction as a function of its location at a given time relative to the space ship in which the trainees are. The crew's mission is to achieve the relative position of the ships (their own stationary one and the model being docked with) in which approach and docking is possible.

Overall control of the trainer and simulators, crew performance of dynamic and logic operations, entry into the trainer of malfunctions or "scenario" data for assessing crew alertness and state of training, storage, processing and output of needed information, recording the course of training exercises and other tasks are performed by a computer complex made up of analog or digital computers with large storage and high response. Control of the training exercise process, monitoring of crew actions, maintenance of communication with the crew, entry into the "flight" program of nonstandard and emergency situations, monitoring the operation of the trainer itself and the computer complex, all of this is effected by using the instructor console placed in the most efficient location for the convenience of the work of the instructors.

Complex trainers allow crew members, in accordance with their duties, to acquire firm skills in controlling the ship and its on-board systems and equipment, in performing the entire flight program from launch to landing, in practicing astronaut interaction with each other and with ground control, in using flight gear, in working with on-board documentation, etc., etc. The complex trainer is called complex because the entire "flight" as a whole is practiced and played on it. Astronauts progress to the complex trainer after studying the complete course of theoretical preparation and rather confidently performing the individual elements of the "flight" program on the specialized trainers, the devices that allow the astronauts to practice the individual, major elements of the forthcoming flight program.

Let us consider, for example, the specialized docking trainer. Just as the complex trainer, it consists of a mockup of the cabin, i.e. the work station of the crew members (as a rule, this is the re-entry vehicle), equipped inside with the actual

instruments and systems pertinent to the operations of rendezvous, approach and docking (other instruments and systems may be mockups). In addition to the mockup of the cabin, the main element in the docking trainer is the docking simulator which we described earlier in discussing the complex trainer. Model movement is controlled by the astronauts by using the actual controls in terms of computers, amplifiers, actuators, etc.

Since docking and subsequent creation in orbit of the Salyut-Soyuz type of scientific research complex are the most important and critical elements in the flight program, substantial attention is paid to practicing rendezvous, approach and docking. Full-scale mockups of the space ship and orbiting station are also used for professional training. These are full-size mockups equipped with actuating instruments, systems and units with which the crew interacts in flight (the remaining apparatus may be a profile mockup).

Full-scale mockups are used for such training exercises as taking motion pictures, temporarily suspending operation and reactivating the station and ship, practicing interaction between crew members in the process of operating in orbit, detailed familiarization and study of the design of the station and all its equipment, arranging and stowing gear, food and on-board documentation, performing scientific and technical and medico-biological experiments in the conditions of the station itself and many other operations.

Used to study the concrete systems of manned flight vehicles are various stands (for example, the stand for the life support system), equipped classrooms, individual prepared and actuating instruments, units and entire systems. Video films play a large role in astronaut training. The training program sections recorded on video film, for example, on the structure of the Soyuz space ship or its on-board systems allow making a detailed study of them. An advantage of these films is the capability of stopping any frame and studying it in detail with adequate quality of the image and definition, and the capability of the television camera during filming to "look" into places of the structure or wiring that are difficult to access during study by a conventional method.

Thus, astronaut training includes facilities for general and professional training that differ in their function, equipment, volume, size and cost. They help develop in the astronauts the professional skills and ability to use the apparatus on-board ships and stations and facilitate understanding of their operation and interaction. And when unusual or emergency situations arise, they help the crew to emerge from the complicated situations with credit by making use of the entire arsenal of their knowledge, considering the possibility of switching to backup systems and knowing of the constant concern of ground control. All training facilities, as a rule, are made as close as possible to actual flight conditions since the astronaut training facilities on the ground are the sole means of preparing for any space flight.

Astronauts are trained at the Center for space flights in two phases. In the first phase, a group of astronauts undergoes general or general space training. This includes theoretical, flight, medico-biological and physical training. At this time, the astronauts study flight dynamics, navigation, astronomy, computers, ballistics, medicine, etc. General training includes studying the basic space ship and

orbiting station, their on-board systems, launch vehicle flight control and launch complexes. Flight training in the first phase consists of flights for weightlessness, studying the starry sky and making astronavigational measurements, and performing flight missions in jet aircraft.

The general space training program is designed, as a rule, for two years. Upon completion of the first training phase, astronauts undergo personal interviews, course tests and examinations. When general training is completed successfully, the crews are formed. According to established experience, the crews are made up of astronauts with space flight experience and those who have completed general space training, but have not yet flown in space. But crew composition may be based on other principles, factors and situations as a function of the flight program, type of ship, flight purpose and duration, etc.

The second phase concerns immediate training for a specific flight and is conducted on a crew basis. The main form of training here includes exercises in various types of trainers, mockups and modeling stands. In this case, a considerable part of the time is spent on detailed study of the flight program, on-board and flight documentation, and techniques for performing various research and experiments. Flight, medico-biological and physical training continues in this period.

In the second phase, astronauts perform training exercises in different climatic regions in the country to acquire skills in making use of whatever is available and the survival kit to survive and stay fit until search groups arrive in event of an emergency landing. These exercises are carried out in unfavorable regions (the desert, steppe, forest and mountains); the crew's task is to properly and efficiently make use of the re-entry vehicle, survival kit, parachute and whatever means are available to survive, and to practice signalling and establishing communications with search groups. In this same period, there are exercises on getting out of the space ship in event it lands in water, or the so-called sea training exercises.

In this period of immediate training, the astronauts have a series of consultations with specialists on the experiments, research and tests planned for the given flight. These may concern the interests of the USSR Academy of Sciences, geo- and astro-physical institutes, the Gostsentr "Priroda" [State Center "Nature"], the ministries of agriculture, fish industry, geology, etc. In the period, the astronauts also study major instruments, such as, for example, the large submillimeter radiotelescope installed on the Salyut-6 orbiting station, the MKF-6 multizonal camera, radiotelescope, etc. In the final stage of immediate training, the astronauts go through final (test) complex training exercises and an evaluation is made of the crew's readiness for flight.

Essential in training crews for flight are the training exercises with personnel in the Flight Control Center to achieve mutual understanding between astronauts in orbit and earth.

If one considers the astronaut training program specifically by its types, then special attention should be drawn to flight training. It is carried out in all phases of training, beginning with the time the astronauts enter the Training Center and continuing from then on irrespective of the number of space flights made by an

astronaut. Flight training is essential in the professional training of all professional astronauts and crew commanders. It is necessary for practicing and maintaining skills in controlling a flying vehicle and for developing and improving qualities such as boldness, composure, and the ability to orient oneself instantly in a complex situation and make the sole correct decision when time is critical. Flight training promotes skills in monitoring instruments to grasp information that is necessary precisely at a given time and in focusing one's attention on the main problems. Finally, in flight training, habits are acquired in the use of flight clothing and altitude gear, in overcoming unpleasant sensations during G-forces and under the conditions of weightlessness, etc.

Medico-biological and physical training are also conducted in all phases of preparing astronauts for flights. Medico-biological training is aimed at developing in the person the qualities that promote enhancement of the human organism's capability of working under the conditions of the unfavorable factors of space flight. Physical training is conducted to maintain and strengthen astronaut health, and to maintain high fitness for work, courage, energy and the state of feeling well with a good attitude.

All forms of training astronauts for space flights complement each other and are aimed at comprehensive and qualitative preparation of the person for carrying out a complex, crucial and at times even dangerous mission.

#### Star City Today

As mentioned before, Star City is in the Shchelkovskiy Rayon of Moscow Oblast. It has its own post office and identification number and, consequently, is a territorial-administrative region within the oblast. If one considers Star City a territorial division of the oblast, then one can say that the Astronaut Training Center imeni Yu. A. Gagarin is located in the territory of Star City. Nevertheless, Star City and the Astronaut Training Center are two parts of an integral whole, and therefore, it is often said that the Training Center has service and residential territories.

The service territory includes the buildings and structures housing the devices, apparatus and facilities used directly for astronaut training. Following is a list of the main buildings. The trainer building, as its name implies, houses the various complex and specialized trainers, mockups of space ships and orbiting station, and stands of the most critical systems in manned space vehicles.

The laboratory and training building houses the classrooms and laboratories used to train the astronauts and perform varied research. Here too are the offices for the Soviet and foreign astronauts used for independent training. Also located here is the training command post for directing training exercises, which simulates the "Zarya" ground control and communication centers. There are also planetariums here.

The hydrolaboratory building houses the hydropool, 23 m in diameter and 12 m deep, with the necessary service and technical apparatus. The large centrifuge, with a shoulder length of 18 m, is in a large, specially designed building. Next to it is the building for preventive medicine. It houses many medical stands, a small centrifuge with a 7 m shoulder, offices for physicians and specialists, and the motion picture laboratory.

In addition, there are administration buildings, a swimming pool, a sports center, motor vehicle facilities, boiler and other center utilites.

The residential territory includes residential buildings, a hotel, shopping center, school, children's center, post office, consumer services center and the other facilities every city needs so that its inhabitants can eat, rest and live a normal life.

Spreading along the shore of a beautiful artificial lake, developed by Star City residents themselves, is the dispensary and hospital. This is where the space ship crews live before flying to the space port since they have to be isolated in the final training phase from the contacts, numerous in everyday life, to avoid an unexpected illness. In the comfortable hall on the first floor of this building, Center directors hold meetings with representatives of other organizations, and representatives of foreign states meet here with their own astronauts. Also taking place here are various types of conferences, exchanges of views, social meetings and other events.

In summer, the lake is a favorite place to rest for the residents of Star City. There is an excellent beach on the shore; ducks and swans swim peacefully on the pond water. On the remote parts of the reservoir, anyone, even the most demanding fishermen, can spend their time profitably and bring home a fine catch. And Star City residents are concerned about this too.

The two 11-story apartment buildings housing the astronauts and their families stand picturesquely against the background of spruce and birch; in front is the square with the Yu. A. Gagarin memorial. Following the concept of the sculptor, Dyuzhev, and the architect, Zavarzin, which was approved by all the astronauts in a discussion on the design, the space pioneer is dressed in the light clothing of a man free of work. A field flower is in his hand behind his back, and he gazes far into the distance. Here, at the Yu. A. Gagarin memorial, where he lived and worked, where he trained for flights and strolled with his daughters, it is never bare. There are always live flowers at his feet, winter and summer.

And while before each space flight the crews are called by their soul to Red Square with a mental vow to perform with honor the mission assigned to them, the Gagarin memorial is where they come after their flights in space to pay a tribute of respect to the man who blazed the majestic trail into space for them.

More than 50,000 representatives of all strata in the society of our country and foreign guests visit Star City annually. And it gets better every year. A fine shopping center has opened; spread around it are tall apartment buildings; there are cafes and dining rooms with inviting and cozy interiors; and hundreds of children enthusiastically play around the heroes of Russian fairy tales, lovingly carved of wood.

Star City's House of Culture, built in the sixties, has been turned into an institution important to the world. Gathered in the exhibits here on the first and second floors is the entire history of manned space flight. Gifts from the workers in our country and from many countries in the world indicate the sincere respect for and pride in Soviet man who dared to fly into unknown space. Here one will find Yu. A.

Gagarin's personal articles; V. M. Komarov's awards and party membership card; P. I. Belyayev's heavy space gear and a remembrance of the Soyuz-11 crew: G. T. Dobrovolskiy, V. N. Volkov and V. I. Patsayev; a wristwatch from F. Borman, the American astronaut, one of the first to go to the moon; the national flags of the countries whose representatives have worked in space under the Interkosmos program; and many other unique and interesting articles and things.

Living in Star City are the people to whom all who have been launched into space are indebted: to their concern, everyday work and perfection of skills. There are too many of these people to list them all, but they are always ready day and night to go to the trainers or control post, to go to the Flight Control Center or fly to the space port to help those who are to perform the space flight so that they can perform the flight in an excellent manner and return to earth without fail.

These specialists are continually gaining experience and absorbing everything that is most necessary so that they can later impart these skills to the next crews and teach them competently and qualitatively. It is therefore no coincidence that at each Center aktiv meeting devoted to a forthcoming flight, the next members of the crews thank with all sincerity and with all their heart these courageous people who know and love their job and who always remain in the shadow of modest workers. Without the everyday, tedious and perhaps at times petty work of these instructors and methodologists, engineers and pilots, physicians and technicians, workers and employees, there would be no flight and no one would be trained for flight.

In 1980, the Astronaut Training Center imeni Yu. A. Gagarin and Star City marked their 20th anniversary. During this time, a large, modern and unique training laboratory, scientific research and flying base was established, and highly skilled specialists have been developed; they have a great deal of experience in training astronauts not only for our national programs, but also in training international crews.

Many astronauts have become doctors and candidates of the sciences; some of them hold high administrative and management positions. The Center has become a post of advanced Soviet science and technology. The Center has also gained international prestige. Scientific conferences and the annual Gagarin lectures are held here. And this is where hundreds of specialists, scientists and designers come to familiarize themselves with the training base and techniques of astronaut training.

The research performed at the Center finds realization in many fields of Soviet science and technology, in improving the space ships and orbiting stations, in their on-board equipment, and in performing experiments and research in space. The center can now be called an academy, a research institute and an international organization.

The basic purpose of the center is to train astronauts. To do this, the Center has the instructors who teach and train the astronauts using the training facilities, the specialists who communicate with the astronauts in orbit, the administrative specialists, the teachers and the engineers.

There are technical training facilities on which mainly the engineers and technicians who service these facilities work. They and the instructors participate

directly in training exercises for the astronauts, perform the necessary equipment repairs and preventive maintenance, and ensure timely incorporation of all changes in the training facilities to conform to a real ship or station.

Medico-biological training is intended for monitoring astronaut state of health, performance of training exercises of his organism, and the state of his fitness for work and spirit. The physicians have at their disposal a wealth of facilities, which were listed earlier.

All the astronauts who have flown and those who have not yet experienced the fascination of space flight are organized into teams. Each has a quite specific task. Some prepare for the next flights, others generalize the experience of flights already performed, or perform research in a chosen direction of work and also prepare for flights, while others stand duty at the Flight Control Center and maintain operation communication with the crews.

And they all, aware of their duty and responsibility, give all their time and themselves to preparing for space flights. This is their purpose, their aspiration, their calling, their duty, finally. And their wives, children, friends and acquaintances help them in this great, noble, but far from easy, labor.

All the Center divisions, the main and the servicing, have one aim: to ensure the continuous operation of all links, large and small, participating in astronaut training. The Center directors and party and social organizations exert great efforts to see that all problems of astronaut instruction, training, work, rest and lifestyle are solved.

Star City is growing and improving. Its residents are growing and improving. They all understand their purpose and do everything that depends on them to see that astronaut training is up to the mark and so that their labor is always attended by the routine TASS announcement: "The space ship with the crew ... is in orbit." For them, this is the highest joy and the event of their entire life.

On 12 April 1981, the whole world marked the 20th anniversary of man's first flight into space. This event was celebrated at Star City; astronauts, veterans of Star City and the Astronaut Training Center, numerous guests and participants in the Gagarin lectures held at this time gathered around the Gagarin memorial.

Not only this event made this year one to especially remember for the Center astronauts and colleagues. The 26th CPSU Congress was held in February in our country; the delegates there included many astronauts too: V. A. Shatalov, G. T. Beregovoy, A. G. Nikolayev, P. I. Klimuk, A. A. Leonov, P. R. Popovich, V. V. Nikolayeva-Tereshkova, A. S. Yeliseyev, O. G. Makarov, V. V. Ryumin, V. V. Aksakov and N. N. Rukavishnikov.

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## COSMONAUT TRAINING SIMULATORS AT 'ZVEZDNYY GORODOK' DESCRIBED

Moscow PRAVDA in Russian 12 Apr 83 p 3

[Article by A. Pokrovskiy (Zvezdnyy gorodok): "Holidays and Workdays of Zvezdnyy"]

[Excerpt] The Soviet and foreign cosmonauts who are busy at Zvezdnyy--and it can now be completely correctly called an international center for training cosmonauts--give the highest assessment to the technical equipment and to the knowledge and teaching skills of its instructors.

"Of course, all this did not come about by itself," says chief of the center, Twice Hero of the Soviet Union, USSR Cosmonaut-Pilot G. T. Beregovoy. "Moreover, when building of the center started, it was required that, practically simultaneously, cosmonauts be trained, technical means for instruction be prepared and cadres of teacher-instructors be trained. I will clarify with one example how complicated these tasks were: even now, when we are adequately equipped with technical means and have built up no little work experience, 2 or 3 years are spent training skilled instructors from among young specialists. Add to this the fact that the technical training facilities also were created basically by the efforts of our center's staff workers, and then the amount of work performed in Zvezdnyy during past years will become clearer.

"Even now," Georgiy Timofeyevich continues, "we face that same three-in-one task--training cosmonauts, equipping the center with modern equipment and training instructors. But now, naturally, the task is being performed on a higher plane. Zvezdnyy itself has grown up, and so have its people. We have two doctors of sciences and 42 candidates of sciences working here. In brief, this is not only a center for training but also, in full measure, for scientific research.

"Obviously, we take an active part in tests of space equipment, and we are conducting solid medical research, especially in the area of the crew members' psychological compatibility. But it must not be thought," notes my collocutor, "that research work is carried out only in our own interests--it is also done, so to speak, for its own sake. We have established close ties with many scientific institutions. Compare these figures: in the first years we collaborated with 3-5 scientific organizations, but now there are about 400 of them, at various levels--from the academy's institutes to VUZ laboratories. Mutual cooperation has been arranged with a number of ministries, especially the Ministries of Geology, Agriculture and the Fishing Industry, and with the State Center "Priroda" [Nature]. Some of them even maintain their own permanent representative at Zvezdnyy. This improves bilateral ties appreciably--specialists of the branches of the national economy get a

better idea of the potential of cosmonautics, and we get a better idea of production requirements."

How would one conceive of the amount of knowledge that a cosmonaut should possess before getting the "OK" for a circumglobal flight? And right away one recalls the half-joking remark of one of them: "The main thing in our job is to pass examinations." And they are not at all like school or VUZ examinations. One may be convinced of this in the hall where the Soyuz T trainer is located. A regular examination was going on their right then. Whew! I would not like to take one before such a commission! About 20 people had gathered in a small room with a control panel and several displays.

"Here are the designers of the craft's main systems, specialists, and, of course, our fellow instructor," explains one of the Zvezdnyy instructors, A. V. Belozerov. "The panel reflects synchronously all the actions of the crew, and, what is more, it can be observed on the television screen. As you see, the Soyuz T is now making an approach to the Salyut--it is still 16 kilometers to the station. How the operation will proceed next depends upon the actions of the crew and...of the commission. From its panel it can introduce so-called 'nonstandard' situations on board. And then the crew has not only to show that it has 'learned the lesson,' but to demonstrate a knowledge of the capabilities and characteristics of the space equipment and skill in making the correct decisions under unusual circumstances."

Here Arnol'd Viktorovich began to hurry:

"It is time to join the commission--my portion of the approach is getting close."

**There is only one crew but it has several instructors, each specializing in a definite topic--Zvezdnyy** trains its students thoroughly, beginning with the rudiments of outer space. I saw how this is being done in an auditorium for technical means of training. At first it seemed to be an ordinary classroom--rows of school desks and blackboards. But when I sat at a school desk, I saw display screens and tape recorder-players to the right and the left. The rear wall of the classroom proved to be glass, and a row of projectors had been arranged behind it. Ahead was a large television set, a motion picture screen, and an instructor's position, which is, simultaneously, the control panel for the auditorium's technical equipment.

All right, we begin the lesson. I turn on my desk's apparatus. On the left an image of the earth rises up, as it appears from orbital altitude. At the right I press the first knob I come to. I check its number with the notebook of descriptions of the transparencies. Aha! a ring of atoll islands, taken from space. So far nothing unusual--now there are space pictures that have been published fairly widely.

"Now take a look at the movie screen," the instructor assumed control. An image of a portion of dry land of complicated relief, also taken from orbital altitude, came on the screen.

"And now a map of that same section, with the remarks of the specialists, to which you must pay attention. Let us combine them," and one image floats over the other. "Isn't it true, isn't this more convenient in preparing for observing objects, especially those which the scientists are interested in, from the Salyut?"

Perhaps it is more convenient, but frankly speaking I did not have the time to look closely. But indeed the cosmonauts observe any area in mere seconds. Right now, just as if it were from orbit, new scenery appears--Baykal's shores.

"Take a look at that same section, which has been photographed in six different parts of the spectrum by MKF-6 apparatus...."

My eyes are dazzled, confronted with six photographs, and the pitiless instructor demonstrates some new technical potential of the auditorium:

"Beside you is a codoscope. Put that diagram in it."

A bright ray of light carries its magnified image to the movie screen. It is convenient, but I feel that the 40-minute lecture is clearly inadequate. I would like to sit down alone and calmly analyze the information received.

"And is it possible to work here independently?"

"Of course the cosmonauts enjoy this opportunity. They scan the transparencies and the videotapes, and the diagrams of the various instruments and systems, and they listen repeatedly to the tape-recorded notes of the lectures."

"But ordinarily their work day is scheduled to the minute?"

"Personal time is left for them...."

I walk from the training buildings, through the whole of Zvezdnyy, to the checkpoint. The cosmonaut's town is not at all like a holiday town right now--it is strict and businesslike. It looks like the cities of miners or metallurgy workers, during the shift change. And indeed, a shift change occurs even here. And the holidays--they still will have them. Holidays engendered by the labor of workers, engineers and scientists--the creators of the space equipment. Holidays engendered by the heroic work of the cosmonauts.

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SCIENTIFIC CONFERENCE TO DISCUSS RESULTS OF EXPERIMENTS CONDUCTED DURING FLIGHT OF INTERNATIONAL SOVIET-VIETNAMESE CREW ON BOARD 'SALYUT-6'

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82 pp 114-115

CHEKALINA, T. I.

[Abstract] From 26 to 28 May 1982, a scientific conference was held in Hanoi, Socialist Republic of Vietnam, in order to discuss the results of experiments performed by the Soviet-Vietnamese international crew on board the "Salyut-6" orbital station from 23 to 31 Jul 1980. The following reports were presented by Vietnamese specialists: "Technical Parameters of Multispectral Aerial Surveying and Processing," "Experiment on the Integrated Interpretation and Investigation of Aerial Photographs Obtained With the MKF-6M Camera," "Preliminary Results of Geological Interpretation of Multispectral Aerial Photographs of the Territory of Several Key Sections of the Da Lat-Phan Rang Test Range Obtained With the MKF-6M Camera," "Brief Description of the Results of Studying Salinization Processes and Determining the Boundaries of the Spread of Flood Waters on the Mekong River Plain by Remote Sensing Methods," "Using Multispectral MKF-6M Photographs to Compile Soil Use Maps (on the Example of Two Test Sections)," "Using Multispectral Aerial Photographs to Compile Agricultural Crop Status Maps," "Preliminary Results of the Use of Multispectral MKF-6M in Investigating and Planning Forests," "Information Content and Methods for Topographic Interpretation of Multispectral Aerial Photographs," "Determining and Improving the Quality of Identification Algorithms Used in Remote Sensing," "Multichannel Spectrometer for Remote Sensing." In addition, a collective of authors from the Administration for Economic Zoning presented a report on the interpretation of multispectral photographs when studying urban economic regions and suburban plant cover.

[52-11746]

## SPACE SCIENCES

### COMMENTARY ON 'ASTRON' SATELLITE

Moscow PRAVDA in Russian 24 Mar 83 p 6

[Article by V. Gubarev: "The Light of Distant Stars"]

[Text] Space apparatuses, the "Astron" among them, always look unusual. It is difficult to find things in our normal environment that look like them or can be compared with them.

"It is something like the towers that I saw in Svanetii," the designer remarked. "But even this kind of comparison is inaccurate. The only thing you can say is that judging from its appearance and size (it is more than 6 meters high), it is easy to guess how much work the scientists and designers put into it during its development. For we had no analogues to work from..."

We are standing in the plant shop where the double of the "Astron," which has already started its journey in space, is located.

"This double differs from the actual model only in that it has no 'overcoat'-- the thermal insulation in which we pack the apparatus before the launch," the designer explains. "The real 'Astron' is like a snowman, but on the double you can see all the design features. It is on this that we worked all possible kinds of tests and generally 'humiliated' it in every possible way," the designer smiled.

He was referring to the numerous tests to which the "Astron" was subjected before it got the "OK" for operation in space.

The development of an essentially new space apparatus is a long and complicated business. It requires many years of work by the project planners, designers and producers. However, during the development of the "Astron" it was decided to use the experience already available at the interplanetary station plant. It was here in its shops that the well-known "Venera" vehicles were made, which went off to the Morning Star and operated on its surface. The interplanetary station was converted into an Earth satellite. However, the flight trajectory for this satellite is unusual: it will go out to a distance of 200,000 kilometers from the planet; there, far from Earth, the perturbations that affect close-earth orbits are reduced to the lowest possible level. The absence of orbit interference makes it possible for the telescopes installed on the station to operate more efficiently.

Telescopes... We have more than once related how cosmonauts carried out astrophysics studies aboard the "Salyuts," They had various kinds of astronomical instruments at their disposal.

"This is my 23d space experiment," says doctor of physicomathematical sciences V. Kurt. "We started as long ago as the third artificial Earth satellite, and then continued the work with the manned and automatic apparatuses. But we are placing our greatest hopes in the 'Astron'..."

"It is essential to obtain new data about the Universe," says corresponding member of the USSR Academy of Sciences A. Boyarchuk. "And this is possible only if we take larger instruments outside the Earth. The 'Astron' is a large flying observatory..."

In science, the desired always comes up against the technical possibilities. It would seem that if you make a larger mirror for a telescope you will see further into the Universe; but the weight of the mirror increases and it begins to sag under its own weight, and then complications immediately arise with other masses... Add to this the vibration and overloads during the launch and the superlow temperatures and high vacuum of space. And the most important thing is the stringent demands on operational reliability, for of course, out there in orbit it is impossible to correct even the slightest error.

"In terrestrial terms an ultraviolet telescope is a large instrument," comments A. Boyarchuk. "The diameter of the mirror is 80 centimeters. At the Crimea Astrophysics Observatory considerable experience has been gained in developing such telescopes and in particular the mirrors for them. However, when developing a space model considerable difficulties are encountered. The mirror must be made to the highest quality and it is only one-third as thick as a mirror used on Earth; and it has to be sent into space, and this means, it must retain its integrity and storeability [sokhrannost'] under the most adverse conditions..."

Don't break the mirror! And so the giant observatory initiated a series of tests on Earth. The designer tried to foresee every kind of unexpected event and they therefore "tortured" the double of the "Astron" in every possible way for a prolonged period and persistently. And it was only after the observatory had conducted all the bench tests without difficulty that it was certain that the launch and the injection into the working orbit could be withstood by the apparatus.

The size of the X-ray spectrometers mounted on the station is less than the ultraviolet telescope, but...

"With the aid of our instruments we can 'look' at virtually any objects," V. Kurt notes. "Even those which, despite every kind of refinement, we cannot see from Earth. The complex is very large. It possesses a number of advantages, in particular it can 'search for' and observe very weak sources, which is extremely important for us. Data processing is organized at the most up-to-date level with the aid of computers. Our instrument will operate along

the most distant parts of the trajectory in the 'Astron's' flightpath. Thus we shall try to avoid the effect of the Earth's radiation belts."

Yes, a complex space apparatus has been launched from our country. What are the hopes that the scientists are placing in it? Why are they talking about a new stage in the development of astronomy?

"We are interested primarily in the so-called nonsteady-state processes," A. Boyarchuk explains. "Many objects provide the most information about themselves in the ultraviolet range, which is absorbed by the Earth's atmosphere. In particular, we hope to obtain information on the overflow of substances in double stars and the reaction between stars and the interstellar medium. We have very little information about 'black holes,' quasars and distant galaxies... It is very tempting to get a closer look at them."

"For example, there is a process known as flares of X-ray radiation that takes place in a star system," adds V. Kurt. "It might be able to tell us a lot and help us to understand what is happening in the depths of the Universe. In general, we are 'flying' so as to familiarize ourselves with unknown stars. And we hope that we shall learn much that is new and interesting."

The hopes are beginning to be justified. The first stage is now behind: the "Astron" has already gone into its calculated orbit. Yet another step toward the stars, toward those lights in the sky that so excite the astronomers.

The "Astron" is the dream of scientists and specialists at the Crimea Astrophysics Observatory, the Institute of Space Research, the Byurakan Observatory and a laboratory in Marseilles (French scientists also participated in the development of the equipment for the station), realized with the aid of powerful Soviet industry. The commissioning of a large telescope on Earth is always an event in this ancient field of human knowledge, but what can we say about a space observatory? In our time we see many rocket launches, but this one is special.

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CSO: 1866/99

## DISCUSSION OF HALLEY'S COMET PROJECTS

Kiev PRAVDA UKRAINY in Russian 7 Apr 83 p 4

[Conversation between Ya.S. Yatskiv and K.I. Churyumov recorded by V. Petrenko]

[Text] The scientists on our planet are waiting with excitement for the meeting with the legendary Halley's comet. They are waiting and making comprehensive preparations for the meeting. This upcoming event was the subject of an international working meeting that opened yesterday in Kiev in which well-known Soviet astronomers and scientists from the socialist countries, and also representatives of "Intercosmos", the European Space Agency and U.S. researchers from NASA, are taking part.

The director of the Ukrainian SSR Academy of Sciences Main Astronomical Observatory corresponding member of the UkrSSR Academy of Sciences Yaroslav Stepanovich Yatskiv and the scientific secretary of the USSR Academy of Sciences Astronomical Council "Kometa" working group, associate of the Department of Astronomy at Kiev University candidate of physico-mathematical sciences Klim Ivanovich Churyumov, talk about this.

K.I. Churyumov: The awaited planet [as published--ed] is named in honor of the English astronomer Edmund Halley, a contemporary and friend of the great Newton. When studying the data then available to science about various comets, Halley found that three of them observed over the same interval of time, in 1531, 1607 and 1682, had very similar orbits. The scientist not only concluded that they were one and the same comet but also predicted its next appearance--in 1759. Halley himself did not live to see this event but his prediction was brilliantly confirmed. The people of Earth also saw the comet "right on schedule" in 1835 and 1910. In all, modern astronomy knows of 29 visits by the comet.

Ya.S. Yatskiv: On its present approach to the Sun Halley's comet was first detected on 16 October 1982. It is now already close to the orbit of Saturn. Moving at a speed of 11.5 kilometers a second, Halley's comet will reach perigee--the point on its orbit closest to the Sun--on 9 February 1986. At

that time it will be "only" 88 million kilometers from our planet and inside the orbit of Venus.

K.I. Churyumov: Halley's comet will be visible to a broad range of observers in Earth in October-November 1985. But it will be brightest in our latitudes during January 1986 when it will be visible a half-hour after sunset as a star with a tail, both through binoculars and with the naked eye. Later, during the second half of January will disappear at dusk. And then it will be visible again (but only in the middle and southern latitudes) in March-July 1986 after it passes perigee.

Ya.S. Yatskiv: Well in advance of this remarkable event scientists from various countries have agreed among themselves a research program and have formed an international service for observing Halley's comet. In our country, on the initiative of the USSR Academy of Sciences Astronomical Council an all-union comprehensive program was been drawn up to study Halley's comet during the period 1983-1987, and last November, as leader of this program, I reported on it at an international conference on studies of this comet held in Budapest.

It is also proposed to study this celestial guest using the same type of scientific equipment located in the northern and southern hemispheres. One of these observation points is close to Kitab in the Uzbek SSR, while a second is located in the mountains of Bolivia in South America.

And finally, the main thing: for the first time in the history of science, space apparatuses with up-to-date, highly sensitive equipment will fly out to the center of Halley's comet,

K.I. Churyumov: It is planned to conduct the "experiment of the century" in accordance with three projects: the Soviet "VEGA" (an acronym for "Venus-Halley"), the Japanese "Planet-A" and the West European "Giotto" (named after the well-known early Renaissance Italian painter who depicted Halley's comet in his "Adoration of the Magi").

The author and scientific leader of the Soviet project--the director of the USSR Academy of Sciences Institute of Space Research academician R.Z. Sagdeyev--has proposed that in order to put the space apparatus on an optimal trajectory to Halley's comet it should fly past Venus and maneuver in that planet's gravitational field. In this way it will be possible to use the same rocket to deliver scientific probes both to Venus and to the comet, which is both more economical and more convenient than studying them separately. In addition to Soviet scientists, their colleagues from the socialist countries, and also France, Austria and the FRG, are working on the "Venus-Halley" project.

According to the plan the Soviet automatic interplanetary station should be launched toward Venus in December 1984. When in June 1985 the station approaches Venus, a descent appratus designed for studies of this planet, will be separated from it. After making a ballistic maneuver in the Venusian gravitational field, the automatic interplanetary station itself will be sent toward its final target, and in early March 1986 it will fly at a distance of about 10,000 kilometers from the center of Halley's comet.

The information obtained by Soviet scientists will be used to guide the "Giotto," which is to approach the "star with a tail" to a distance of 500 kilometers.

Ya.S. Yatskiv: The range of scientific tasks that can be resolved through these three planned space missions to Halley's comet is very broad. Probing its center will help scientists to check many ideas and hypotheses about the physics and chemistry of comets and questions connected with their origin. And since comets are apparently relict aggregates of substances from the same solar nebula that served as the "building material" for all the bodies in the Solar system, scientists are hoping to obtain in these experiments very valuable information, including information about the problems of the origin or life of Earth and in the universe.

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## FLIGHT CONTROL CENTER'S HISTORY, FUNCTIONS SPOTLIGHTED

Moscow KRASNAYA ZVEZDA in Russian 25 Mar 83 p 4

[Article by Engr-Col M. Rebrov: "Control Center"]

[Text] "This is 'Dawn'! How do you read me? How are things in orbit? This is 'Dawn,' over!"

Imagine the number of times that the Flight Control Center, with its call sign "Dawn," has summoned "Pamirs," "Protons," "Elbruses," "Urals," "Burans" and "Saturns" working in outer space....

The voice of man had been carried into the depths of the Universe long before Yuriy Gagarin's flight. There was nothing out of the ordinary in this radio transmission that departed from the planet of Man. Quite simply, radio was the first invention to break out of the constraining limits of the globe. The possibility is not excluded that the radio wave which had hurled decades ago into outer space carrying the sound of human speech is now vibrating somewhere beyond the Solar System, near the star Alpha Centauri or in other places, incredibly attenuated and distorted.

But what about radio signals from outer space? No, not natural, but of man's doing? They were first received in the night of 4-5 October 1957. I read the following entry in the operations log maintained by telemetrists at Baykonur: "Received signal from launch vehicle. Satellite separated from launch vehicle, required speed attained...." But actually, everything started long before.

In the mid-1950s, when preparations were still being made for launching of the first satellite, Soviet scientists and engineers were already working on the design of technical resources required for dependable operation of the earth-space-earth radio bridge. On the suggestion of S. P. Korolev and M. V. Keldysh these resources came to be called the command and control complex.

"Without information from orbit," said Korolev, "the value of any flight would be zero. And if this information is to come in constantly and completely, a great deal of electronic equipment would be required. Equipment that never fails. If this is to be, then everything on earth and in space must be

excellently matched, tuned and tested down to the last contact, down to the tiniest terminal and wire.... As they leave earth behind, cosmonauts must feel that their craft is an inseparable part of our planet...."

Flight control is a very broad concept. It means forecasting the motion of satellites, orbiting laboratories and interplanetary stations, monitoring the state and operation of their onboard systems and machine units, evaluating the completeness with which the intended flight program is fulfilled, making decisions in routine and nonroutine (emergency) situations, revealing causes of malfunctions and working with the crews. And all of this is done by the services of the command and control complex, which includes the Flight Control Center and a number of ground measurement stations.

However, ground stations are not enough. Out of every 15 or 16 orbits that "Soyuz" or "Salyut" vehicles make each day, six go beyond the limits of our country's territory. Their flight could be observed, information could be received from space and instructions could be transmitted to the vehicles during this time only with the help of special expeditionary vessels located at certain points on the World Ocean. They monitor what we call the "invisible" orbits, when the spacecraft or station is not visible to ground measuring stations.

This celestial flotilla has its own history. At first the space watch was stood by aging ships leased from the Ministry of Maritime Fleet: the freighters "Krasnodar" and "Il'ichevsk," the tanker "Aksay" and the small steamship "Dolinsk." Today, giants like "Akademik Sergey Korolev," "Kosmonavt Yuriy Gagarin," "Kosmonavt Vladimir Komarov" and new telemetric vessels go to work at sea. No matter what the weather, oblivious to storms and hurricanes, they are out there, keeping the communication lines open.

But let's get back to the Flight Control Center. It is the point of convergence of numerous lines of a perpetually operating electronic conveyor which carries commands and inquiries in one direction and highly detailed information on everything going on in orbit in the other. Let me note that a complex consisting of the "Salyut," "Soyuz" and "Progress" vehicles carries thousands of sensitive sensors which transmit, at a frequency varying from once a minute to a hundred times a second, coded signals containing information on the state of onboard systems, on how the apparatus is functioning, on the measurements that are made, and on the results that are obtained.

Information plunges from outer space like a Niagara of numbers. Its volume in just a single communication session is equivalent to the number of printed symbols contained in a 3-month volume of KRASNAYA ZVEZDA. How do we handle this deluge? One of the operators answered this question in this way: "It is not enough to know that a person we are speaking with is French. We must also understand his speech, we must know French. And so it is with us: First of all we must learn to understand what the numbers coming from orbit are trying to say."

Of course, high performance computers are helping the people. They make it possible not only to process the giant flows of information but also to graphically display the basic results in real time. As an example, using trajectory

measurements the computers determine the actual orbit, they "superimpose" it over the calculated orbit, and depending on the discrepancies they forecast the subsequent motion of the craft or station, and the ballistics experts make decisions on correcting the trajectory.

Celestial mechanics is an exact science. It is so exact that, for example, the times of solar eclipses can be calculated centuries into the future. And rest assured that the moon will cover the sun exactly "on schedule." The center's specialists also work with numbers that allow them to predict the "fate" of celestial bodies. The only difference here is that these bodies are artificial, manmade.

Yes, the quantity of numbers is enormous. They stand for volts and amperes, kilowatts and hertz, hours and kilometers, orbits and communication sessions, temperature and humidity, the concentration of carbon dioxide in the atmosphere of the working compartments of a "celestial home," the pulse and pressure of the crewmembers, the level of cosmic radiation outside the craft and the density of the micrometeorite flux, and the number of times scientific apparatus is turned on. In a word, they stand for all without which "the value of any flight would be zero." Displayed in the form of tables and graphs, and of infinite series of mathematical symbols on television screens, electronic light signal panels and illuminated maps of the Flight Control Center, these data provide silent commentary on what is happening many hundreds, thousands and millions of kilometers away.

Here is another important point. Flight control could be reliable only on the condition that all telemetric and orbital measurements and that all instances of signal reception and transmission are coordinated in time, and with the highest precision moreover. For this purpose all ground and floating measuring stations are equipped with highly stable clock-oscillators making up a single time system. The precision of the "movement" of these clocks is plus or minus a second in 10,000 years.

We are now in the main hall of the Flight Control Center. A huge screen bearing an elaborate map of both hemispheres extends from floor to ceiling, and beside it is an electronic light signal panel that shows the time, the serial number of the current orbit, the orbit parameters and other information. Five rows of consoles fill up the entire space of the hall. The duty shift is now sitting at these consoles.

On occasion a bright spot appears and begins to move along one of the oval rings crossing the territory of the Soviet Union. This is the way the zones of radio visibility of the ground measuring stations appear on the map. In some place the tangle of rings resemble the "Olympic" emblem.

There are other halls besides the main hall. The center personnel work in them as well as in special buildings housing particular subdivisions (they are called functional groups). Each work station is furnished with several television monitors that display information. Trajectory data, telemetric records and the televised view from aboard the craft are all transmitted here simultaneously. There are about 500 monitors, and information is transmitted

to them via 150 channels. A specialist need press only a couple of keys to display the data he needs on the screen.

There is a maze of corridors on each floor of the Flight Control Center. There are instrument control rooms wherever you look. The nameplates on the doors provide an indication of not only the professions of the people working behind them but also of the complexity of the "organism" itself of the Flight Control Center. "Planning Group," "Analysis Group," "Experimental Group," "Operational Telemetric Information Group," "Ballistics Group," "Medical Group," "Search and Rescue Group".... They are all dependably linked to their representatives sitting in the main hall.

I have perhaps never before experienced such an acute purely journalistic interest toward people. I could have listened to them for hours, for several evenings in a row. But this would have required a minimum of a year, considering the diversity of professions represented by the workers of the Flight Control Center: ballistic experts, radio operators, telemetrist, instrument controllers, medical specialists, biologists, onboard system specialists, cosmonauts, communications experts, programmers....

Also among them we can find those who had taken part in the creation of this highly complex ground space complex. The way they tell it, the call-sign "Dawn" originated with Gagarin's flight. "Dawn" was the name given to the apparatus created for communication with "Vostok." The system of radiotechnical resources that came to bear this name was developed by a collective of designers under the guidance of Prof Yu. S. Bykov. As with many other things in the history of Soviet cosmonautics, it was the first in the world.

"Every time another spacecraft takes off," said USSR State Prize Laureate A. Militsin, the director of the Flight Control Center, "our collective's spirits soar. Especially interesting, creative work begins. Work which--we know this quite well--will produce new discoveries, new joys. But with them, there will be new troubles as well. The flight will make it known: Had the center prepared correctly for its mission, will it be able to resolve the complex situations that might arise?"

Gagarin's successors to the stars took over where he left off: 108 minutes, a day, a week, a month, 2 months, 96, 140, 175, 185, 211 days. Imagine how titanic an effort was invested by the center's specialists into each of these trips into outer space!

"Concentration, always ready to transform into conscious and precise action.... Necessarily precise, because there can be no misfires in our work," said USSR State Prize Laureate V. Blagov, the deputy flight director, and he went on:

"The personnel must maintain such a state for several hours at a stretch and overall, throughout the entire time of a flight. No matter how long it lasts."

Every minute, every instant of the engrossing and tense days in outer space making up the 211 day journey of A. Berezovoy and V. Lebedev has become history.

One looks back and mentally resurrects all of the stages of this unprecedented flight, and one thinks of the people in the command and control complex. And even though "Salyut-7" is now flying in automatic mode, their work continues.

The new shift took over today at the center in routine fashion. Today will be a difficult day: work with "Salyut-7" and with the satellite "Cosmos-1443," reception of telemetric data from the orbiting observatory "Astron." But things were not any easier for yesterday's shift.

Regular, unyielding collection of information from outer space--hour by hour, day by day--provides us with important and valuable things, things which enrich our experience and knowledge, widen the horizons of science and open up the prospects of tomorrow's cosmonautics.

#### PHOTO CAPTIONS

Above: Emblem of the control center and the main hall of the Flight Control Center

Below: Long-distance communication antennas and the expeditionary vessel "Kosmonavt Vladimir Komarov"

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UDC 629.015 + 531.38

FAMILIES OF SPATIAL PERIODIC ORBITS IN HILL PROBLEM AND THEIR STABILITY

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 10 May 82) pp 3-11

LIDOV, M. L. and LYAKHOVA, V. A.

[Abstract] Results are shown from numeric calculations of parameters in Lo families of spatial periodic orbits in the Hill problem, with special attention given to orbit stability. The equations for the Hill problems in canonical form are defined by the Hamiltonians shown. Numeric characteristics of Lo orbits are close to those of Bo orbits. The Lo families are generated from given unidimensional periodic orbits forming the Bo family. Initial conditions for orbits in the family  $Lo^k(i-j, N)$  are shown and their stability examined. Figures 9; references: 3 Russian.

[88-9642]

UDC 629.015

SYSTEMS OF ARTIFICIAL EARTH SATELLITES IN STABLE CIRCULAR 24-HOUR ORBITS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 26 Apr 82) pp 12-19

VASHKOV'YAK, M. A. and LIDOV, M. L.

[Abstract] The authors consider the problem of determining parameters for the movement of a system of Earth satellites in near-circular orbits with a period of approximately 24 hours, such as to insure a given stability for the tracks above the Earth's surface and stability of the angular spacing between any two satellites along their tracks, over a period of several years. The problem is stated and the evolution of the system of orbits is examined. Proceeding from the initial values for the duration of the ascending node and initial orbital inclination, changes in these elements. Examples are shown of the satellite systems being considered. It is concluded that it is possible to use the proposed calculation method of simple approximation analysis in order to determine the main qualitative

characteristics of movement perturbation in satellites in stable circular orbits over a period of the order of 5 years. Figures 4; references 5: 3 Russian, 2 Western.  
[88-9642]

UDC 629.015

#### OPTIMUM CONTROL OF ELEMENTS IN A PLANAR ORBIT CLOSE TO THE CIRCULAR

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 26 Aug 81) pp 20-26

AKULENKO, L. D.

[Abstract] The author considers the problem of time-optimal control of the movement of a space vehicle in a near-circular planar orbit using only low-power thrusters. The problem is stated as a combination of essential optimality conditions in the form of a maximum principle and asymptotic methods for nonlinear mechanics (the averaging method). The methodology used in considering the problem is that of Cheronbus'ko-Akulenko et al. (1980). The two-point problem of time-optimal control is examined. Asymptotic methods, including averaging, are used extensively in problems involving space vehicle dynamics and control and can be equally used in controlling variable orbital elements in a spatial case, as for example, orbital inclination and duration of ascending node. Using the proposed method, the time-optimal control problem is considerably simplified for a marked elliptical orbit, while for other cases it can be solved numerically with the aid of a computer. Figures 3; references 10: 7 Russian, 3 Western.

[88-9642]

UDC 629.7.015: 531.38

#### FASTEAST REORIENTATION OF ROTATION AXIS IN DYNAMICALLY SYMMETRIC SPACE VEHICLE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 5 Oct 81) pp 27-33

GORELOV, Yu. N.

[Abstract] The author considers the variational problem of moving the axis of rotation in a dynamically symmetric space vehicle in the shortest possible time, seeking the solution among the class of movements involving a single alteration of this axis. The problem is stated and calculations are shown for the movement of the space vehicle during the maneuver, disregarding perturbation factors and change in the moment of

inertia, proceeding from the Euler dynamic equations; the variational problem is formulated and solved. Angular velocity before and after rotation is assumed to be the same, with the axis of rotation fixed in inertial space, and control is effected by two engine systems, one creating control moment in the equatorial plane of the vehicle and the other regulating the angular velocity of rotation about the axis of symmetry. An optimum equation is obtained, assuming that angular velocity is controlled during the maneuver. The variational problem is generalized. Figures 3; references: 7 Russian. [88-9642]

UDC 629.783/785

#### ALGORITHM FOR OPTIMAL PLANNING OF OPERATION OF SPACE APPARATUSES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 23 Apr 81) pp 34-40

SOLLOGUB, A. V.

[Abstract] Methods are considered for optimal planning for the operation of space vehicles. An algorithm is shown describing optimal planning, based on the ideas of dynamic programming; the stages of its derivation are shown. Combined information on the greater dimensionality of problems and the lesser dimensionality of "elementary" tasks make it possible to substantially reduce the volume of calculations and obtain solutions close to the optimal, making use of iterative and recursive-iterative methods. The question of the amount of labor involved in the algorithm is discussed. Methods are shown for selecting optimal values for parameters characterizing the process of sectionalization, assuming that indivisible problems are solved using the exhaustive search method. No references. [88-9642]

UDC 519.68

#### ALGORITHM FOR DETERMINING SENSOR DISCRIMINATION IN MEASUREMENTS OF RANGE AND VELOCITY IN RELATIVE MOVEMENT OF TWO SATELLITES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 2 Oct 81) pp 41-46

BERMISHEV, A. A., BRAGAZIN, A. F. and SHMYGLEVSKIY, I. P.

[Abstract] An algorithm is shown for recurrent redetermination of range and velocity measurements for the relative movement of two satellites along a line of sight by evaluating systematic error in measurements of sensor

discrimination. An equation is shown for the algorithm and two possible approaches to determination of unobserved coefficients of discrimination are discussed: the approaches consider ways of finding values for assessing linear combinations and a priori constraints on the values for the coefficients. The practical applications of the algorithm are considered. It is shown that use of the algorithm can be in some cases considerably simplify determination of range and velocity in the relative movement of two satellites. Figures 2; references 2: 1 Russian, 1 Western.  
[88-9642]

UDC 523.72

FINE STRUCTURE OF MAGNETOPAUSE FROM READINGS TAKEN BY 'PROGNOZ-7' AND 'PROGNOZ-8' SATELLITES

Moscow KOSMICHESKIYE ISSLEDUVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 23 Mar 82) pp 57-63

VAYSBERG, O. L., GALEYEV, A. A., ZELENYY, L. M., ZASTENKER, G. N., OMEL'CHENKO, A. N., KLIMOV, S. I., SAVIN, S. P., YERMOLAYEV, Yu. I., SMIRNOV, V. N. and NOZDRACHEV, M. N.

[Abstract] The authors analyze three intersections of the magnetopause distinguished by the abrupt nature of the plasma boundary. Measurements for the analysis were obtained in 1980 and 1981 using the SKS-04 selective plasma spectrometer, the "Monitor" fast plasma spectrometer and ultralow-wave detectors. Two of the intersections were recorded in direct transmission mode, thus enabling the evolution of the energy spectrum at the plasma boundary to be monitored. A burst of lower hybrid fluctuation was recorded and its role in the formation of the magnetopause structure determined. Details of the measurements are shown and discussed from the viewpoint of present ideas on nonlinear saturation of drift instability at a frequency close to the lower hybrid resonance. It is concluded from the analysis that small-scale lower hybrid instability is a typical feature of the structure of the magnetopause that does not significantly affect the large-scale structure but does influence processes locally. Figures 4; references 5: 1 Russian, 4 Western.  
[88-9642]

UDC 550.383

STUDY OF PLASMA MANTLE IN EARTH'S MAGNETOSPHERE

Moscow KOSMICHESKIYE ISSLEDUVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 7 Jan 82) pp 64-75

PISARENKO, N. F., DUBININ, E. M., ZAKHAROV, A. V., LUNDIN, R. and  
HULTQVIST, B.

[Abstract] The ion structure of the plasma mantle was studied from data obtained from the "Promiks-1" equipment installed on the "Prognoz-7" satellite launched 31 October 1978. The plasma ion component was analyzed at the boundary layer in the high latitudes and in the polar cusp, and the existence of a source of ion acceleration located at altitudes  $8-10R_E$  on the auroral force lines of the daytime polar cusp was demonstrated. The high apogee of the "Prognoz-7" (about 200,000 kilometers) enabled measurements in the high-latitude fields of the magnetosphere inaccessible to earlier satellites (Heos-2): measurements were made of energy characteristics for electrons and ions in the range 0.01-50 KeV/q and of ion mass within the range 1-20 amu and 0.2-17 KeV/q. Full details of measurements are shown. Results are extensively discussed from the viewpoint of acceleration mechanisms, with reference to the role of ion-cyclotron turbulence in ion acceleration. Figures 7; references 20: 3 Russian, 17 Western.  
[88-9642]

UDC 550.388.2

LINK BETWEEN INTENSITY OF SPORADIC RADIATION IN EARTH'S MAGNETOSPHERE  
WITHIN FREQUENCY RANGE 0.7-2.3 MEGAHERTZ AND STREAMS OF SOFT ELECTRONS  
(0.2-10 KeV)

Moscow KOSMICHESKIYE ISSLEDUVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 11 May 81) pp 76-82

ARTEM'YEVA, G. M., PISAREVA, V. V., SAVIN, B. I. and TARASOV, A. F.

[Abstract] A comparative study is made of results from measurement of the intensity of sporadic radio emissions in the magnetosphere within the frequency range 0.7-2.3 megahertz and irregular soft electron streams at energies of 0.2-10 KeV. Data were obtained from equipment aboard the "Elektron-2" and "Elektron-4" satellites. Maps are compiled showing the distribution of electron streams on day and night sides, based on the different data from the two satellites. Comparison shows that on the nighttime side maximum frequency of soft electron streams occurs within a closed field of magnetic force lines corresponding to latitudes  $60-78^\circ$  at a distance of  $4-6 R_E$ , mainly close to the location of maximum intensity of sporadic radio emission; the afternoon and evening maxima also occur at latitudes below  $78^\circ$ . Radio emissions observed have some characteristics

similar to those of auroral kilometric radiation. Possible mechanisms for the occurrence of radiation at these great distances from the Earth are discussed. Figures 3; references 13: 7 Russian, 6 Western.  
[88-9642]

UDC 523.035: 525.72

HELIM ATOMS IN INTERSTELLAR AND INTERPLANETARY MEDIUM, PART 1:  
OBSERVATIONS OF SCATTERED ULTRAVIOLET RADIATION IN LINES HI LAMBDA  
1216 $\text{\AA}$  AND HeI LAMBDA 584 $\text{\AA}$  FROM 'PROGNOZ-5' AND 'PROGNOZ-6' SATELLITES

Moscow KOSMICHESKIYE ISSLEDUVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 4 Sep 82) pp 83-94

BURGIN, M. S., KURT, V. G., MIRONOVA, Ye. N., PROKHORENKO, V. I.,  
EYSMONT, N. A., BERTAUX, J-L., and DALODIER, F.

[Abstract] The joint Franco-Soviet "Interplanetary Helium" experiment, designed to investigate the interstellar background simultaneously in lines HeI lambda 584 $\text{\AA}$  and HI 1215.7 $\text{\AA}$ , is described. The experiment was conducted during the period 1976-1978 using the "Prognoz-5" and "Prognoz-6" Soviet satellites on which the French MPG multichannel photometer was installed. The experimental conditions, instrumentation and processing of experimental data are described in detail. Experimental results are presented in graphs and tables to show the basic information received from the satellites during observations. Illustrations of intensity distributions show that the satellites were rotating stably during observations and confirm the correctness of reconstructed intensity distributions. The processing and interpretation of results from this experiment to determine the parameters of the interstellar wind from data obtained from the helium channels of the equipment are to be the subject of a later paper. Figures 5; references 12: 4 Russian, 8 Western.  
[88-9642]

UDC 519.25

METHOD FOR DETERMINING VELOCITY OF CENTER OF MASS IN A SPACE VEHICLE FROM  
RESULTS OF TRAJECTORY MEASUREMENTS

Moscow KOSMICHESKIYE ISSLEDUVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 15 Sep 80) pp 116-119

BRASLAVETS, R. I. and MEN'SHIKOV, A. V.

[Abstract] A method is proposed for determining the velocity of the center of mass in a space vehicle from trajectory measurements, taking into account displacement of the onboard transponder antenna relative to

the center of mass. The problem considered is for the case of velocity measurements made from two onboard transponders located at different points not coinciding with the space vehicle's center of mass, and two ground measuring systems. The method is illustrated by working through a numeric problem of this class. Requirements for accuracy in trajectory measurements can be formulated with this method such as to insure a given loss in accuracy when switching from random points in a space vehicle to its center of mass. References: 3 Russian.  
[88-9642]

UDC 629.785

MAXIMIZING ACCURACY IN AUTONOMOUS NAVIGATION WITH MEASUREMENTS OF ANGLES BETWEEN DIRECTIONS FROM ARTIFICIAL EARTH SATELLITE AND KNOWN STAR AND NONASSIGNED GROUND LANDMARK

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 11 Jan 82) pp 125-127

VINOKUR, M. I.

[Abstract] A method is shown for redetermining the trajectory of a space vehicle on its approach to a planet at times  $t_1, t_2, \dots, t_n$  by measuring angles  $\gamma_1, \gamma_2, \dots, \gamma_n$  between the directions of the vehicle and a previously unknown ground landmark and a known navigational star lying in the plane of the orbit. The movement of the vehicle relative to the landmark is described by a five-dimensional vector for parameters  $q = (e, a, \tau, \omega, u_0)$ , where  $e$  is the orbital eccentricity,  $a$  the major semi-axis,  $\tau$  the moment of passage across the pericenter,  $\omega$  the argument of latitude for the pericenter, and  $u_0 = \omega + \eta_0$ , the argument of latitude for the landmark, while  $\eta_0$  is its true anomaly. The problem is worked for two orbits and the degree of error is determined. Figures 2; references: 5 Russian.  
[88-9642]

UDC 537.525.1

POSSIBLE MECHANISM FOR ION ACCELERATION IN AREA OF DAYTIME POLAR CUSPS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 31 Dec 81) pp 135-137

LIPEROVSKIY, V. A., SKURIDIN, G. A. and SHALIMOV, S. L.

[Abstract] Quite strong Birkeland points, longitudinal electric fields and a high level of low-frequency electrostatic wave turbulence have been observed in the auroral magnetosphere. In those areas where the points are

intense enough to make the magnetic field commensurable with the Earth's magnetic field, spatial structures of the Alven "magnetic hawser" type may be formed, as, for example, in the area of the distant daytime polar cusp. It is suggested that the laws of full current and magnetic flow retention apply about the tube of force; in this case, the relationship of the disturbed magnetic field to the external field at distance  $R$  from the Earth's center at the intersection at  $3.2R_E$ :  $\delta B_1/B(R) = (1/15)(R/3.2R_E)^{3/2}$ . Thus, for the area of the distant polar cusp at  $R \sim 10R_E$  we obtain  $\delta B_1/B(10R_E)^{1/3}$  since the disturbed and external magnetic fields are comparable and the continuation of the longitudinal current in this case evidently corresponds to the "magnetic hawser" structure. Since the Alven-type "magnetic hawser" is a current-carrying formation, it is suggested that above a certain critical value, current instabilities develop and ion-acoustic turbulence and anomalous resistance occur. The "magnetic hawser" is not a steady-state structure; a scheme for its evolution is shown. The significance of the transverse acceleration of ionospheric ions is discussed in light of recent observations conducted using the "Prognoz-7" satellite. References 12: 4 Russian, 8 Western.  
[88-9642]

UDC 524.1-732

#### DISTRIBUTION OF GAMMA-BURST SOURCES IN SKY AND BURST OF 13 JUNE 1979

Moscow KOSMICHESKIYE ISSLEDUVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 1 Feb 82) pp 137-139

ESTULIN, I. V. (deceased)

[Abstract] The distribution of sources for the numerous gamma bursts recorded by the "Konus" equipment aboard the "Venera-11" and "Venera-12" is analyzed. Histograms are constructed to show the differential distribution of sources on galactic latitude  $b_{II}$  and the shortest gamma-bursts recorded. In field  $b_{II} = -(15+5)^\circ$  a peak is observed in which 24% of all localized gamma sources are concentrated, suggesting recurrent bursts in this area. However, although sources of gamma bursts have been identified earlier at  $F_{XP} 0520-66$  and  $B1900+14$ , this cannot be considered final proof of recurrent sources since in most cases determination of these sources was not sufficiently accurate. More accurate data are needed to finally resolve the question. Details of the gamma-burst recorded 13 June 1979 are shown. Figures 2; references 10: 5 Russian, 5 Western.  
[88-9642]

INTERPLANETARY SCIENCES

TASS ANNOUNCES LAUNCHING OF 'VENERA-15'

Moscow PRAVDA in Russian 3 Jun 83 p 1

[Text] In accordance with the program for the study of space and the planets of the solar system, the automatic interplanetary station "Venera-15" was launched in the Soviet Union on 2 June 1983.

The purpose of the launch is to continue scientific studies of the surface and atmosphere of the planet Venus by research conducted in orbit as an artificial satellite of the planet.

Specialists of the German Democratic Republic participated with Soviet specialists in creating the scientific apparatus of the station.

The "Venera-15" station was placed in an interplanetary trajectory from an intermediate orbit as an artificial earth satellite. According to ballistic measurements the parameters of the flight trajectory are close to planned values. The station should reach the vicinity of Venus in the beginning of October 1983.

The on-board systems and scientific apparatus of the "Venera-15" station are operating normally.

CSO: 1866/149-P

**TASS ANNOUNCES LAUNCHING OF 'VENERA-16'**

**Moscow PRAVDA in Russian 8 Jun 83 p 1**

**[Text]** In accordance with the program for study of space and the planets of the solar system, the automatic interplanetary station "Venera-16" was launched in the Soviet Union on 7 June 1983.

The "Venera-16" station is similar in design and mission to the "Venera-15" station which was launched on 2 June 1983. The trajectory parameters of the station are close to planned values.

Both the "Venera-15" and "Venera-16" stations will reach the vicinity of the planet in the beginning of October 1983.

The flight of the "Venera-15" and "Venera-16" stations will provide the opportunity to perform independent complex measurements over various regions of Venus. The scientific studies which will be performed simultaneously by the two stations from orbit as artificial satellites of Venus will significantly expand the body of information about the surface and atmosphere of the planet which is the closest to the Earth in the solar system.

The flights of the "Venera-15" and "Venera-16" stations are being controlled from the Long-Range Space Communications Center.

The on-board systems and equipment of the stations are operating normally.

CSO: 1866/150-P

## INTERACTION OF SOLAR WIND WITH MAGNETOSPHERE OF VENUS

Moscow PRAVDA in Russian 10 Jan 83 p 7

[Article by T. Breus, branch chief, Institute of Space Research, candidate of physical and mathematical sciences and K. Gringauz, laboratory manager, Institute of Space Research, professor and Lenin Prize laureate: "The Only Non-Magnetic Planet--Science Expands Our Horizons"]

[Text] A very important and interesting era in our study of the planets began when the existence of so-called solar wind was discovered in 1960 with the assistance of the first Soviet lunar space vehicles. These currents of plasma originating at the sun's corona partially encompass the solar magnetic field and "draw" it out into interplanetary space.

Non-uniformity in the structure of the solar corona and the transience of its processes determine a non-uniformity and fleetingness in the properties of solar wind, the medium in which the planets exist. The velocity and concentration of interplanetary plasma and the size and direction of the interplanetary magnetic field may therefore vary substantially. The density of solar wind is very low and its magnetic field quite weak.

How then do the planets react to such an ephemeral phenomenon? It turns out that the interaction of atmospheres, ionospheres and the magnetic fields of the individual planets with solar wind and the interplanetary magnetic field comprise a special area of planetary physics which is quite significant.

The initial discoveries in this sphere were made, naturally, with respect to the earth. As we know, earth has a strong magnetic field. It has been established that solar wind meets this obstacle as it nears our planet and skirts around it. As a result, the solar wind seemingly draws lines of force of the earth's magnetic field out away from the sun, creating a so-called magnetospheric tail hundreds of thousands of kilometers in length and about 200,000 km in cross section. Meeting an obstacle in its path, the supersonic solar-wind current slows down abruptly and a shock wave is formed in it similar to that of an airplane flying in the atmosphere at supersonic speed.

In 1967 the USSR Academy of Sciences Institute of Space Research conducted plasma measurements and the Institute of Earth Magnetism and Radio Wave Propagation took magnetic readings in the vicinity of the Morning Star from the Venera-4 space station.

Additional plasma measurements were taken in 1968 from Venera-6. These data showed that our neighboring planet also has a shock wave. But this one is situated much closer to the planet's surface--at a distance of approximately 2000 km from the side nearest the sun. However, Venus is a practically non-magnetic planet.

This circumstance corroborates the theory of the origin and sustainment of planetary magnetic fields--the so-called planetary dynamo theory. According to this theory, a planet which has its own magnetic field must have a rather quick rotation rate and a liquid, conductive core in which currents are generated upon rotation, creating the magnetic field. This point of view would explain the observed phenomenon through the slow rotation rate of Venus.

But if this is the case, what then serves as the obstacle that applies the brakes to the solar wind at the planet's surface and forms the shock wave?

The first Soviet modern-generation, unmanned stations, Venera-9 and -10 (1975-1976), became artificial satellites around the planet. For the first time, they enabled research to be conducted with respect to the region shadowed from the sun's rays and solar wind currents by the planet. The most interesting result turned out to be the discovery of a plasma-magnetic tail of great length.

It turns out that not only a shock wave, but a magnetosphere quite similar to that of a planet possessing a strong magnetic field of its own appears in the vicinity of the non-magnetic planet. How have these been formed?

The ability to compare data gathered simultaneously at two stations (Venera-9 and -10) has aided Soviet specialists in understanding the nature of these phenomena. It has become clear that the magnetic field in the Venus's tail has an inductive nature. As already mentioned, the solar wind current carries the interplanetary magnetic field with it as it flows around the planet. This induces electric currents in its ionosphere which create their own magnetic field. This field forms the "magnetic barrier," hinders the solar wind current, deflects it and creates a shock wave.

Other no less significant results directly associated with features of the interaction between Venus and the solar wind are related to properties of its ionosphere. The Venera-9 and -10 satellites also conducted research in these areas.

Radio-eclipse observations of Venus's atmosphere gathered by artificial satellites (conducted by the Radio Engineering and Electronics Institute of the USSR Academy of Sciences) yielded data which were used to study the behavior of the upper border of ionosphere, the ionopause, where the concentration of the planet's own ionospheric plasma drops about one hundredfold in a small altitude interval. It turns out that the current of solar wind plasma acts on the magnetic barrier, exerting pressure on ionospheric plasma in the region near the sun and forcing it closer to the planet's surface. Phenomena of this nature are not observed for other planets that are protected from the direct influence of solar wind by their own magnetic field.

Thus, based on Soviet research conducted on Venera-4, -6, -9 and -10, it has been established that the big picture of the interaction of solar wind with Venus and with Earth resemble one another on the surface--both planets have a shock wave and a magnetosphere with elongated tail. However, the nature of the plasma and magnetic

phenomena discovered and the mechanism by which they interact with the solar wind are completely different in the case of Venus than for Earth. These results were published in 1977 and confirmed in 1981 through data from the American space vehicle Pioneer.

We currently have information on magnetospheres of the planets from Mercury to Saturn. Venus is the only planet known that has practically no magnetic field of its own, yet possesses a magnetosphere. Detailed research on the magnetospheric structures of Venus and the other planets is possible only through the use of space vehicles, and has a significance which goes beyond the scope of the study of planets.

Apparently, magnetosphere-like formations are spread throughout the universe. As well as appearing in conjunction with bodies and systems that have their own magnetic field, they may be seen in the vicinity of objects without one--comets, for example. Interaction between the solar system and currents of ionized, interstellar gas flowing around it causes the formation of a huge, magnetosphere-like structure--the "heliosphere." The environs of galaxies may consist of "magnetospheres" on a vast scale. The possibility of magnetic tails stretching out behind them with complex structure has not been ruled out. Thus, in the cluster of galaxies of the Perseus constellation there exists a radio galaxy (visible only in the radio wave band) having a magnetic tail hundreds of thousands of light years in length.

All of this sheds additional light on our concept of the structure of the universe.

9768

CSO: 1866/73

UDC 528.711.1(202): 523.4

## RESULTS AND PROBLEMS IN MAPPING PLANETS AND SATELLITES

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 12, Dec 82 pp 55-58

TYUFLIN, Yu. S.

[Abstract] Soviet work on mapping planets and satellites using automatic space stations is traced, starting from the "Luna-3" which transmitted the first pictures of the dark side of the Moon on 7 October 1959. Problems of developing coordinate systems for mapping are discussed. A list is provided of the main Soviet organizations involved in cartographic work on celestial bodies. The work of the Central Scientific Research Institute of Geodesy, Aerial Photography and Cartography and the Moscow Institute of Engineers of Geodesy, Aerial Photography and Cartography in compiling maps of the Moon, Mars and Venus is described. Technical and mathematical problems in data acquisition and processing are considered, with particular reference to the use of space photographs as a basis for establishing reference points on the surfaces of planets and satellites. One specific problem remaining to be solved is making accurate determinations of the heights of particular points on the surfaces of planets and satellites; in addition to using stereophotogrammetric methods it is necessary to employ profiling from automatic space stations, radiotechnical observations from the ground, barometric methods, bistatic radar, and radio eclipse methods. The ultimate purpose of mapping the planets and satellites of the solar system is to gain a better understanding of phenomena occurring on Earth and of the origin and development of the Solar system. No references.

[121-9642]

METHODS FOR COMPREHENSIVE POSTFLIGHT BALLISTIC ANALYSIS OF DESCENT TRAJECTORIES FOR 'VENERA'-TYPE LANDERS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 1 Jul 82) pp 47-56

AVDUYEVSKIY, V. S., IVANOV, N. M., MOMTSULEV, B. I., POLYAKOV, V. S. and TIKHONOV, V. F.

[Abstract] A method and algorithm are proposed for comprehensive postflight ballistic analysis of the descent trajectories of "Venera" landers based on the specific parameters of the descent trajectory, planetary atmosphere and the lander itself, as obtained from "service" data sent from the space vehicle. The method involves a step-by-step solution of the problem, enabling a substantial reduction in the amount of work involved, greater clarity of results, and the possibility of using different methodological approaches in solving individual parts of the analytical task. The following elements of the problem are considered: determining conditions during the lander's entry into the atmosphere; establishing the lander trajectory in the atmosphere; determining the coordinates of the landing site on the planet's surface. A simulation model of the appropriate onboard systems was constructed to investigate methodological and instrument error in the operation of onboard equipment and error in the weight and aerodynamics of space vehicle models. Features of the Venusian atmosphere and other random factors affecting the movement of the vehicle were also considered. An evaluation is made of expected accuracy in determining control parameters using various criteria of quality, together with methods for finding guaranteed evaluations of the accuracy of results. Test modeling showed that error in determination of the lander's reentry angle is less than 0.4-0.5° using the method and algorithm described; error in determination of landing site coordinates is 15-30 minutes. Figures 2; references: 5 Russian.

[88-9642]

EVALUATION OF AEROSOL CONCENTRATION IN UPPER CLOUD LAYER OF VENUS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 4 May 82) pp 106-110

COROSHKHOVA, N. V. and PETROVA, Ye. V.

[Abstract] Results are analyzed from a more accurate calculation of the coefficient of extinction within the range 200-1400  $\text{cm}^{-1}$  for the aerosol medium made up of particles of a 75-percent sulfuric acid solution, as part of the study of infrared heat radiation on Venus. A more accurate determination of this coefficient enables comparison with values obtained in

radiometric experiments conducted by Soviet and U.S. researchers, and also makes it possible to indirectly determine the concentration of  $N_o$  particles in the upper Venusian cloud layer and compare results with the experimental data of Marov et al., obtained using the "Venera-10" instrumentation. Data on  $H_2SO_4$  refraction are taken from the published work of Jones (1976). The method of calculation is shown in detail. Spectral dependence of the coefficient of extinction for the range 300-570 and 700-1340  $cm^{-1}$  is shown in graphic form and discussed relative to the radiometric measurements. The results indicate that the contribution of the aerosol mode to absorption is insignificant. Reasons for disagreements with the radiometric findings are examined. Figures 2; references 14: 5 Russian, 9 Western.

[88-9642]

UDC 550.383

#### NATURE OF MAGNETIC FIELDS IN VICINITY OF MARS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 28 Aug 81) pp 111-115

DUBININ, E. M., IZRAYLEVICH, P. L., PODGORNYY, I. M. and SHKOL'NIKOVA, S. I.

[Abstract] An analysis is made of data from magnetic measurements conducted by the "Mars-3" and "Mars-5" interplanetary probes from the viewpoint of effects associated with the lateral components of the interplanetary magnetic field (IMF), in an attempt to clarify the nature of the Martian magnetic fields. Using the  $X_{IMF}^{IMF} Y_{IMF}^{IMF} Z_{IMF}^{IMF}$  system of coordinates, it is shown that in the neighborhood of Mars an area exists in which the direction of the magnetic field does not correlate with the lateral component of the IMF. The field in this area cannot be explained by envelopment along the IMF lines of force, and appears to be Mars' own magnetic field. The structure of the Martian magnetosphere is discussed within the context of solar wind interaction. Figures 3; references 18: 7 Russian, 11 Western.

[88-9642]

#### INVESTIGATIONS OF VENUSIAN MAGNETOSPHERE REVIEWED

Moscow ZEMLYA I VSELENNAYA in Russian No 1, Jan-Feb 83 pp 36-40

PODGORNYY, I. M., doctor of physical and mathematical sciences

[Abstract] The magnetic field near Venus can be attributed not only to the currents flowing in the planet itself, but also to the effect of a cosmic magnetohydrodynamic generator. When a magnetic tail was discovered on the nighttime side of Venus it seemed a convincing argument that Venus

had its own field. The processing of a great volume of data from the "Venera-9" and "Venera-10" seemed to make everything fall in place, but an analysis made by Ye. G. Yeroshenko completely reopened the question. Yeroshenko compared the direction of the field in the solar wind and in the tail of the Venusian magnetosphere. That analysis was possible only in the presence of two artificial satellites of Venus. It was necessary to analyze those radio contacts when one of the satellites was in the tail of the magnetosphere and the other was in the undisturbed solar wind. It was found that the direction of the field in the tail was related to the direction of the field in the interplanetary medium. This relationship can only be attributed to the formation of an induced magnetic field near Venus. By this time the USSR Space Research Institute had already carried out the first experiments in modeling such a magnetosphere (ZEMLYA I VSELENNAYA, No 3, pp 32-38, 1977). The basic conclusions of Ye. G. Yeroshenko were in essential agreement with the predictions from laboratory modeling, but many problems remained unresolved. Further investigations were carried out: refinement of a three-dimensional laboratory model of the induced magnetosphere and careful processing of magnetograms for determining the sign of the transverse field component in the tail. In laboratory experiments the solar wind was simulated by a supersonic flow of hydrogen plasma; all other parameters were selected so as to duplicate the phenomena transpiring near Venus. A small wax sphere was placed in the vacuum chamber. The wax was sublimated and the sublimation products were ionized by electrons of the artificial solar wind and ultraviolet radiation. This created an artificial ionosphere around the sphere. This made it possible to form a shock wave near a body with a plasma shell in the absence of an intrinsic magnetic field; the general features of the induced magnetosphere were found. The model suggested that Venus should have a quite dense ionosphere on the nighttime side, although there is no ionizing UV radiation there. Subsequent investigations revealed or confirmed many more details. It appears that the configuration of the Venusian field, in any case its greater part, is created by unipolar induction. Many important studies concerning the Venusian magnetosphere and ionosphere are continuing.

Figures 5.

[62-5303]

## LIFE SCIENCES

### COMMENTARIES ON SUCCESSFUL PLANT GROWING EXPERIMENTS ON 'SALYUT-7'

#### Lithuanian Originators Interviewed

Moscow PRAVDA in Russian 31 Dec 82 p 3

[Article by D. Shnyukas, PRAVDA correspondent, Vilnius]

[Text] For the return of the "El'brusites" to Earth, the collective of scientists in the Laboratory of Plant Physiology at the Lithuanian SSR Academy of Sciences' Botany Institute prepared an unusual gift for A. Berezovoy and V. Lebedev. *Arabidopsis* shoots had grown in a number of test tubes. These were special--one could even say "space"--plants; their seeds were obtained on the "Salyut-7" station from seeds that had been planted there. Thus, for the first time it was proven that even under conditions of weightlessness, plants can complete the entire cycle of biological development.

Senior Scientific Associates Romual'das Laurinavichyus and Al'gidras Yaroshiyus place a rack of test tubes on a table.

"Of the 18 seeds planted here," explain the directors of the laboratory, "7 grew to maturity. However, this in no way detracts from what has been achieved. We're not yet interested in productivity..."

The institute was invited to participate in the space research because it had considerable experience in working on the gravitational physiology of plants. The initiator and enthusiastic supporter of this work was Al'fonsas Merkis, now the director of the institute and an academician of the Lithuanian SSR Academy of Sciences.

Various plants--peas, wheat, goosefoot--were used for experiments before the modest, unpretentious *arabidopsis* was finally selected. Its vegetative cycle lasts only 1 month and it fertilizes itself even in a sterile environment. In a word, it is an extremely appropriate candidate to become a "cosmonaut."

In the laboratory, those involved started to create their own "space greenhouses," or biological units: "Fiton" and "Biogravistat." They were built by engineers and workers at the Vilnius branch of the Experimental Scientific Research Institute of Metal-Cutting Machine Tools. In collaboration with the USSR Academy of Sciences' Institute of Space Research and Institute of General Genetics and the Ukrainian SSR Academy of Sciences' Institute of Molecular Biology and Genetics, as well as others, step-by-step the scientists in Vilnius delved into the mysteries of space.

The first results were not very encouraging: the arabidopsis did not produce seeds. Then the men from Vilnius undertook to improve the instrument. As a result, "Fiton-3" differed noticeably from its predecessor. It was that biological unit that fell into the hands of A. Berezovoy and V. Lebedev.

"The cosmonauts turned out to be rare executors and good growers," remarks Romual'das Laurinavichyus. "When Leonid Popov, Aleksandr Serebrov and Svetlana Savitskaya arrived at the station on board the 'Soyuz T-7' on 20 August, Valentin Lebedev gallantly greeted the lady with an arabidopsis that was blooming in the 'Fiton-3'."

Svetlana Savitskaya took the instrument back to Earth. When Romual'das Stasevich saw the results of the experiment in Moscow--tall stalks, pods that had burst and seeds scattered about inside the instrument (in all, there were about 200 of them)--he had a good feeling in his heart. Now the most nerve-racking phase of the experiment could begin: would the seeds from the plants grown in space produce shoots?

However, the matter could not be hurried: the seeds had to go through a resting stage. They were "planted" on 5 November. Green shoots appeared on the fourth day, and now the "cosmonaut" arabidopsis is flowering and growing seed pods...

"The investigation into the physiology of plants under conditions of dynamic weightlessness gave us a very important answer," Al'fonsas Merkis says in summation. "However, in science there are no stopping points. The results that were obtained evoke new hypotheses and raise new theoretical problems. We will continue our investigations with the help of the 'Fiton-3' instrument. Then we will look forward to the 'Neris,' in which two modes--gravity and weightlessness--will be created in parallel."

#### Plan of Experiments Summarized

Moscow PRAVDA in Russian 31 Dec 82 p 3

[Article by A. Mashinskiy, candidate of biological sciences]

[Text] There has very likely never been a manned flight when plants in various growing devices were not present on board the spacecraft. This means seeds, and strawberries, and onions, and full-grown plants, and even cuttings from apple trees. This is a development of the ideas of K.E. Tsiolkovskiy, who started from the necessity of creating, for a man in the cabin of a spaceship, those conditions that can support his normal vital activities.

Long before the first orbital stations appeared, Academician S.P. Korolev formulated the entire program for research utilizing plants: "It is necessary to begin to develop 'Tsiolkovskiy greenhouses,' with gradually increasing numbers of branches or units, and it is necessary to begin working on 'space crops.' What will be the composition of these plantings, what crops will be used, and what will be their effectiveness and usefulness? The convertibility (repeatability) of plantings from their own seeds follows from calculations of the extended existence of these greenhouses."

This is the program that is now being realized in scientific orbital stations. Right now it is already possible to say with confidence that the first stage of the research has been completed successfully: the fundamental possibility of the passage of plants (or at least such self-fertilizers as arabidopsis) through their entire cycle of development under conditions of weightlessness has been demonstrated.

This experiment, for all practical purposes, removed the "prohibition" on the possibility of growing plants under conditions of weightlessness or, more accurately, under the conditions of spaceflight, which had caused serious concern among a number of investigators. However, this indisputable success raised some new problems. First of all, it is necessary to determine the cause of certain changes that did take place in the plants and to learn how to grow them and achieve a high yield. For all practical purposes, there has appeared a new experimental field in science: space agriculture.

Valeriy Ryumin, who has spent almost a year in space, assembled and "started" the "Oazis" and "Malakhit" systems in orbit. They were used to cultivate various plants, even including such exotic ones as orchids. And to these orchids belongs a unique record: they grew in space for almost half a year and then were returned to Earth, where they were studied at the Ukrainian Academy of Sciences' Central Republic Botanical Garden and other scientific establishments throughout the country.

A. Berezovoy and V. Lebedev continued the "agricultural work" in space. They had another "Oazis" unit. The planted area was enlarge by a factor of 2-2.5, a new water supply system was introduced and aeration of the root zone was provided for; this, under conditions of weightlessness, is probably a very important agrotechnical measure. The plants were subjected to electrical stimulation. Other space technology methods were also used: the amount of light furnished the plants depended on their size, water was supplied where it was needed at a given moment, the mineral nourishment conditions were improved. These matters were taken care of by specialists at the All-Union Institute of Biotechnology.

There was also an auxiliary "Orbita" unit on board the station that was used to grow lettuce, cucumbers, radishes and even such an interesting plant as borage, which is a nectariferous plant having large amounts of vitamins. It is on the basis of these little grains that space agriculture is being created.

One of the key problems in space biology has now been solved: seeds have been obtained under spaceflight conditions. However, there remain problems concerned with improving the technology for growing plants under spaceflight conditions, designing space greenhouses and selecting the proper plants. The results obtained so far make us fully confident that this program for research in space will be implemented successfully.

11746  
CSO: 1866/72

## NEW BOTANICAL EXPERIMENTS PLANNED

Moscow TASS in English 24 Mar 83

[Text] The "Crocus" experiment is planned to be held on a Soviet biological satellite. New explorations will help scientists get an answer to questions of development of higher plants in weightlessness conditions.

The full cycle of development of higher plants from seed to seed was observed only in the case of arabidopsis. Other plants would not produce seed in outer space. Scientists hypothesize that a cotton-wool filter, located in the unit, where arabidopsis was growing, might detain harmful micro-particles and elements.

Space biologists have long been trying to establish if there is a fundamental ban on penetration of the live organism into the universe. This problem is important for the future of cosmonautics and also for fundamental science.

Specialists received as a great accomplishment the fact that arabidopsis burst into blossom and produced seed in the "Fiton" unit aboard the "Salyut-7" station for the first time in the history of space biology.

Its flowers were presented by cosmonauts Anatoliy Berezovoy and Valentin Lebedev to Svetlana Savitskaya when she appeared aboard the station. Savitskaya brought to earth 200 arabidopsis seeds.

How "Crocus" will fare in outer space is to be shown when it is in orbit.

CSO: 1866/107-F

UDC 629.78: 616.211-018.73]: 001.8

STUDIES OF VASCULAR RESPONSE OF NASAL MUCOSA IN COSMONAUTS

Moscow VESTNIK OTORINOLARINGOLOGII in Russian No 5, Sep-Oct 82  
(manuscript received 9 Mar 82) pp 44-46

YAKOVLEVA, I. Ya., doctor of medical sciences, and BARANOVA, V. P.,  
candidate of medical sciences, Institute of Medico-Biological Problems,  
USSR Ministry of Health

[Abstract] As a result of the redistribution of blood and fluids in the upper half of the body during weightlessness, nasal deposits without any symptoms of rhinitis are found in cosmonauts during the initial adaptation to weightless conditions. This phenomenon was studied in 36 cosmonauts aged 25 to 45 of whom 14 had participated in space missions of varying duration. Intranasal resistance was investigated with the aid of a Soviet-produced rhinopneumometer with subjects seated, recumbent and again after returning to the sitting position. Subjects participating in space missions were examined before and after flight. No marked differences were found in nasal resistance resulting from body position, but in some subjects intranasal pressure increased 2-3 millimeters water when moving into the horizontal position; in 3 of 5 subjects with slight curvature of the nasal septum, after 15 minutes in the horizontal position intranasal resistance increased 17-18 mm. water; return to the horizontal position was accompanied by rapid restoration of the initial values. In subjects with vasomotor changes in the mucosa, intranasal pressure in the horizontal position reached 18-20 mm water and restoration of initial values was slow (3-5 minutes). Of the 14 subjects participating in space missions, 9 noted symptoms typical of blood redistribution in the upper half of the body 1-3 hours after the onset of weightlessness; in some, these symptoms occurred after 1-3 or 5-6 days; nasal deposits usually coincided with changes in pneumometry values. The findings indicate the significance of nasal reactions in impairment of nasal breathing during adaptation to weightlessness. A modification of the experimental method could be used for quantitative evaluation of changes in nasal breathing from the vasomotor component and to predict vasomotor reactions in the nasal mucosa during the acute period of adaptation to weightlessness. References 6: 5 Russian, 1 Western.  
[114-9642]

## SPACE ENGINEERING

### RENDEZVOUS IN SPACE

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 2, Feb 83 pp 40-41

[Article by O. Georgiyev, candidate of technical sciences]

[Text] Among the problems of maneuvering in orbit one of the most interesting is that of a rendezvous between two space vehicles. In its resolution, one of the space vehicles usually plays an active role while the other remains passive. A typical example of this kind of distribution of roles is provided by the transport "Soyuz" or "Progress" freighter (the active space vehicle) moving to rendezvous with the "Salyut" station (the passive space vehicle). It is precisely this kind of space program that we have in mind in what follows.

The scheme for solving the rendezvous problem, or more precisely, the scheme for a flight involving a rendezvous, comprises several phases. The first is accomplished even before the vehicle is injected into orbit and is preparatory. During this phase the station already in flight must burn its engine in a predetermined way to alter or correct its own movement so that at the moment of separation the orbital parameters of the station and its position in this orbit will satisfy certain predetermined conditions. This preparatory phase is called the formation of the assembly orbit.

During the second phase--that of injection of the artificial earth satellite into orbit--the vehicle is still not ready to carry out its active role; it is merely the payload of the carrier rocket. But in this phase a number of questions insuring successful completion of the rendezvous are resolved. First and foremost, the problem of injecting the vehicle into the plane of the assembly orbit is resolved (otherwise during rendezvous energy-consuming maneuvers will be required to match the orbital planes of the rendezvousing space vehicles). In addition, during the injection phase a predetermined range of distances is set up between the passive and active vehicles at the moment when the latter is injected into orbit. The tasks in this phase are resolved by the choice of the date and moment of the launch of the carrier.

Turning to a description of a rendezvous carried out by the active space vehicle, let us use an example to clarify the physical basis of the solution to this problem. Let the initial moment of the station be at a certain point  $P$  in a circular assembly orbit at a height of  $H = 350$  km, and let the vehicle

p

be injected into a circular orbit at a height  $H_a = 200$  km (figure 1); the periods of these orbits are  $T_p = 91.54$  minutes and  $T_a = 88.49$  minutes. At its own position in the orbit  $P$  (point A) let the vehicle remain one-fourth of a revolution from the station ( $\phi_0 = 90^\circ$ ). Angle  $\phi$  is called the phase misalignment, or phase; the value of the initial phase  $\phi_0 = 90^\circ$  corresponds to a distance of about 10,500 km on the orbit. Let us assume that our problem is to complete the rendezvous after exactly 10 orbits of the station.

Let us assume that the vehicle does not maneuver, that is, during the course of time set aside for the rendezvous it moves along its initial orbit. After 10 orbits or 915.4 minutes of flight the station again assumes its initial position  $P$  in the assembly orbit, and at this moment the vehicle has completed 10.34 revolutions in its initial orbit because the period of its assembly orbit is less. The excess of 0.34 of a revolution over 10 complete revolutions corresponds to angle  $\Delta\phi = 122^\circ$ . Thus, the vehicle has not only closed the initial phase lag of  $90^\circ$  behind the station but has even overtaken it by  $32^\circ$ .

The process of altering the phase misalignment between the space vehicles during flight is called phasing. In our example, the phasing rate ( $122^\circ$  in 10 revolutions, or  $12.2^\circ$  per revolution of the station) was too high and the initial phase could have been eliminated after only 7.5 revolutions. It is clear from the example that it is possible to regulate phasing rate by altering the orbital period of the maneuvering vehicle.

In order to alter the period of orbit or any other parameters the space vehicle has a single means--the engine--which makes it possible to correct the speed of the vehicle's orbital movement. What changes in speed can provide the desired change in orbit? For a simple answer, let us assume that we are dealing with circular (or near-circular) orbits at heights of 400-500 km and that the speed of the vehicle's orbital movement changes instantaneously when the engine is firing (this change is usually called impulse speed, or just impulse for short). These assumptions make it possible simply and with sufficient accuracy to evaluate the effect of altering orbital speed. Let us consider the numerical characteristics for an impulse of magnitude  $\Delta v = 1$  meter per second.

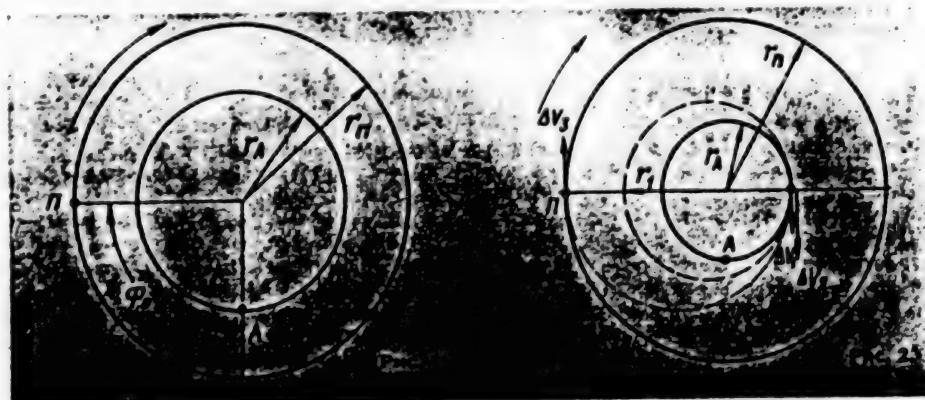
Let the impulse direction be transverse, that is, match the direction of the orbital speed. As a result of its action, all points on the orbit are, as it were, distanced from the point where the impulse is applied, and the distance will be greatest after half a revolution and lead to an increase of 3.4 kilometers in the height of the orbit and increase the orbital period by 0.034 minutes.

If the impulse direction is radial (matching the direction from the center of the Earth to the point where the impulse is applied) then the orbit will be completely shifted into the direction of the orbital speed, and the height will be increased by a maximum of 0.85 km after one-fourth of a revolution following impulse, and decrease a maximum of 0.85 km after three-fourths of a revolution following impulse, while the height of the orbit at the diametrically opposite point and the orbital period remain unaltered.

If the impulse direction is normal to the plane of the orbit, then following impulse the plane of the orbit will be turned about the radial direction, and maximum lateral orbital shift of 0.85 kilometers will occur after one-fourth and three-fourths of a revolution following impulse (the direction of shift through one-fourth of a revolution matches impulse direction) and the height and period of the orbit remain unchanged.

If the impulse direction is reverse, the changes in the orbit characteristics will also be reverse. Moreover, if impulse speed increases (or falls) several times over, then the changes in orbit parameters will also increase (or decrease) by the same amount. Since random impulse can be shown in the form of the sum of its radial, transverse and normal components, change in the orbit resulting from the action of such an impulse is shown as the sum of the changes resulting from the action of each of them.

Returning to the question of phasing, we can now see that a change in the orbital period of the active vehicle is insured by impulse possessing a transverse component.



Figures 1 and 2. Schemes for Passive and Active Phasing

Up to now we have been talking about eliminating the phase misalignment between the space vehicles. But the fact of rendezvous is recorded at the moment when phase, height and lateral misalignment, all three, are zero, that is, when the realtive distance between the space vehicles is zero. Let us use an example to show how height and phase misalignment can be eliminated simultaneously.

Let a vehicle in the initial conditions shown in figure 1 be switched from its initial orbit to an elliptical orbit after three-fourths of one revolution of flight by impulse  $V_1$  (figure 2). At the point of impulse the height of the orbit remains unchanged, equal to  $H_a$ , but at the diametrically opposite point the height changes to  $H_1 = H_a + 3.4 \Delta V_1$ ; the period of orbit now becomes  $T_1 = T_a + 0.034 \Delta V_1$ .

Having completed a certain complete number of revolutions  $N$  in elliptical orbit, the vehicle uses transverse impulse  $\Delta V_2$  again to alter its orbit in such a way that its height at the diametrically opposite point is equal to the height of the assembly orbit  $H_p$ . The value for the second impulse is determined by the formula

$$\Delta V_2 = \frac{H_p - H_1}{3.4}$$

According to this formula the period of orbit after application of the second impulse becomes:

$$T_2 = T_1 + 0.034 \Delta V_2 = T_1 + 0.034 (\Delta V_1 + \Delta V_2) = T_1 + 0.01 (H_p - H_1) \approx 90 \text{ min.}$$

Finally, at the point of contact between the assembly orbit (point P) and the orbit of the vehicle reached after the second impulse, the orbit of the vehicle is once again altered by a transverse impulse

$$\Delta V_3 = \frac{H_p - H_1}{3.4},$$

and thus its height at the opposite point also becomes  $H_p$ . With this last impulse the transfer of the vehicle from initial orbit to assembly orbit is complete.

Let us determine the time of the flight for the vehicle from its initial position to the point of transfer to the assembly orbit. During the course of this flight the vehicle completes three-fourths of a revolution on the injection orbit ( $0.75T_1 = 66.37$  minutes),  $N$  complete revolutions on the elliptical orbit with period  $T_1$  ( $N T_1$ ), and half a revolution on the elliptical orbit with period  $T_2$  ( $0.5 T_2 = 45$  minutes). Since the point at which the rendezvous is planned should be reached by both space vehicles simultaneously, it is necessary to fulfill the condition:

$$10 T_1 = 0.75 T_1 + N T_1 + 0.5 T_2 = 0.75 T_1 + N T_1 + 0.034 N \Delta V_1 + 0.5 T_2.$$

After inserting the numerical values this conditions becomes:

$$\Delta V_1 = \frac{804.03 - 88.49 N}{0.034 N}.$$

The formula obtained makes it possible, with  $N$  selected, to determine the value for  $\Delta V_1$ , and then, from formulas already to hand, the other parameters needed to solve the rendezvous problem. These parameters are shown in the table below for three values for  $N$ .

$N, \text{БИТ-НОВ}$	$\Delta V_1, \text{м/с}$	$\Delta V_2, \text{м/с}$	$\Delta V_3, \text{м/с}$	$H_p, \text{км}$
8	353	-309	44	1401
9	25	19	44	285
10	-238	282	44	-609

A positive sign for  $\Delta V$  means that the impulse is directed about the orbital speed (in acceleration) and a negative sign, that impulse is directed against it (deceleration). To select an acceptable value for  $N$  it is only necessary to use common sense. First of all, the case where  $N = 10$  is virtually unrealizable because movement with a negative number for  $N$  is unrealizable. A solution for  $N = 10$  is inadvisable in terms of energy since total change in orbital speed, or total impulse, in this case is 706 meters per second,

against 88 meters per second for  $N = 9$ . A large total impulse means a large fuel consumption by the engine, and accordingly the most economical, or optimal in terms of energy, is the version  $N = 9$ .

The example considered is only a partial, simplified model for solving the rendezvous problem, but it does make it possible to understand that solving this problem depends largely on initial data (initial phase and height misalignments between the space vehicles) and the schemes for the flight (spacing of impulses on the orbital revolutions, time duration for the rendezvous part). Practice not only gives rise to a variety of initial data but also places quite strict demands and constraints on the flight pattern during rendezvous.

In the example considered the first engine burn on the vehicle took place during the first revolution on the injection orbit. Can this be done in practice? In principle, yes, but this kind of haste may be ill advised. The fact is that the vehicle is injected into an orbit whose parameters usually differ to some degree from the calculated parameters. And in order to find out the actual parameters of the injection orbit, trajectory measurements must be taken and processed. And as a rule this takes two passes of the vehicle over the control consoles of the command-measuring complex. Then it is necessary to solve the rendezvous problem and transmit the results in a form "understood" by the vehicle control system. Thus, the first impulse should in practice be applied only on the third revolution in the flight. Taking into account all the features of the operation of ground and onboard control complexes, it is recognized that it is most advisable to apply the first impulse no earlier than the fourth revolution of a flight to the "Salyut."

The approach considered is also correct subsequently, since any impulse can occur in a way other than calculated and with certain errors. Moreover, if we do not take new measurements of the vehicle's orbit our knowledge of its movement at any given moment is based on results from processing past measurements "elongated" in time. This elongation contains error, since we do not know with absolute accuracy the forces acting on the vehicle from outside, and in calculations we use only a model of them. And even the past measurements included some error. This all means that we always know the orbit of the vehicle with some error, and if measurements are not "fresh" these errors increase with time. Hence the practical conclusion: after the first impulses for rendezvous our knowledge of the orbit must be made more accurate. For the "Soyuz" new measurements are taken on the fifth and sixth revolutions of its flight, and after this, right up to the 13th revolution it is not within range of the tracking stations located on our territory. This period (called the "blind revolution") is usually used as a sleep period for the crew, while control of the onboard systems is done by the vehicle's measuring points. From the viewpoint of ballistics the "blind revolution" makes a fully constructive contribution to solving the rendezvous problem (remember the  $N$  revolutions for phasing in the example we considered).

Another constraint is the height of the flight. In practice it is considered undesirable if the minimum height of the orbit falls to 130-150 km.

Let us limit this list of ideas about the practical plan and note that up to now we have been speaking about the phase of the rendezvous that is called the distant phase. After this phase, automatic rendezvous is effected and the practical problem of rendezvous has been completed.

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9642

CSO: 1866/95

UDC 629.782

DESIGNING OPTIMAL FILTER IN PROBLEM OF CONTROLLING ARTIFICIAL EARTH SATELLITE WITH AID OF FLYWHEEL

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 22 May 81) pp 119-120

BELEN'KIY, A. D.

[Abstract] The problem of designing an optimal filter for a single-axis satellite stabilization system using a flywheel motor is considered, taking into account system status vectors, maneuvering effect, angular error in satellite stabilization, the difference between the satellite's absolute angular velocity and the applied velocity relative to the flywheel's rate of rotation, the flywheel's and satellite's axial moments of inertia, the flywheel's relative rate of rotation, the satellite's external perturbation angular velocity, and the perturbation angular velocity of the flywheel. The equations for solving the problem are shown. Figures 1; references: 2 Russian.  
[88-9642]

UDC 629.197

ESTABLISHING EXTENDED LINK BETWEEN TWO ORBITING BODIES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 21 Oct 81) pp 121-124

LEVIN, Ye. M.

[Abstract] A simple method is proposed for establishing extended links (of the order of tens of kilometers) between two bodies in geocentric orbit, using only the tension in the cable linking the two bodies. The problem is considered for a probe body linked to a carrier body by a flexible weightless cable, with the two bodies moving about the Earth under its gravitational pull, with the center of mass for the cable moving along an

elliptical orbit. The effect of cable tension is considered and equations are shown describing horizontal oscillations in the probe about the vertical drift and oscillations along the direction of the normal to the plane of the orbit. It is shown that the class of movements considered in a link of variable length in an elliptical orbit can be used for smooth linkage of orbital systems using cables. Figures 2; references 11: 7 Russian, 4 Western. [88-9642]

UDC 629.197

POWER GYROSCOPE WITH ELECTROMAGNETIC BEARINGS FOR CONTROLLING ORIENTATION OF ORBITAL STATIONS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 1, Jan-Feb 83  
(manuscript received 29 Mar 82) pp 139-142

SHEREMET'YEVSKIY, N. N., VEYNBERG, D. M., VERESHCHAGIN, V. P. and  
DANILOV-NITUSOV, N. N.

[Abstract] The design requirements for gyrodyne electromagnetic bearings are discussed as applied to the orientation of space vehicles, and possible ways of meeting these requirements are considered. The basic parameters of the bearing include the ability to reorient a space vehicle in 10-15 seconds; the question of bearing strength is examined. Factors involved in control of the bearing are discussed. An electromagnetic bearing was fabricated and tested experimentally; the main design characteristics of this bearing are shown and experimental results are presented. It is concluded that electromagnetic devices can be incorporated in large power gyroscopes for use in orientation systems for space vehicles. Figures 2; references: 4 Russian.  
[88-9642]

## SPACE APPLICATIONS

### SPACE SURVEY TECHNIQUES BENEFIT GEOLOGY

Moscow IZVESTIYA in Russian 15 Jan 83 p 3

[Article by USSR Deputy Minister of Geology V. Volkov: "Geology and Space"]

[Text] For many branches of this country's national economy, the beginning of the space era opened new paths for development. Above all, this applies to geology. Our geological service immediately became the main consumer of space information. Space photographs cover vast areas, so large geological structures that cannot always be studied by traditional methods of geological investigation are visible in them. Images of geological objects that are not visible on the surface appear frequently in space photographs.

Projects for the discovery of new deposits of useful minerals that are conducted on the basis of the extensive utilization of photographs from space consist of a number of sequential stages. Initially, comparatively small-scale, specialized cosmogeological and mineralogenetic-prediction maps are compiled from space photographs. Elements of the structure of the Earth's crust to which increased concentrations of useful minerals can be confined are isolated on them. During the second stage, on-site confirmation of the results of interpreting the space photographs is carried out. The projects are completed by purposeful prospecting for deposits.

Cosmogeological cartography is now being done on a systematic basis and encompasses this country's entire territory. Specialized maps with images of large structural elements discovered with the help of space surveying materials have been compiled for the first time in world practice. They include a cosmogeological map of linear and ring structures in the USSR and a cosmophototectonic map of the Aral-Caspian region. During the 10th Five-Year Plan, cosmogeological cartography on scales of 1:1,000,000-1:500,000, with compilation of the corresponding maps, was done for vast areas of this country. The very first of these maps was created for the area of the BAM [Baykal-Amur Main Line], and is contributing to the accelerated geological study of that region. Cosmogeological maps have also been compiled for extensive territories in Krasnoyarsk Kray, Yakutiya, the northeastern USSR, Western Siberia, Western Kazakhstan and other regions. As a result of this work, the structural plan of many regions has been refined, new regularities in the location of useful mineral deposits have been discovered and specific recommendations have been made for the direction of future geological exploration work. During this five-year plan we are planning to continue cosmogeological cartography work and to complete it for the entire country by 1990.

In the process of regional mineragenetic-prediction research using space survey materials, the first thing that is done is a detailed analysis of the ore nodes and zones in which deposits of useful minerals are already known to be concentrated. In a number of regions this has made it possible to define more precisely the contours of previously detected ore nodes and trace new continuations of ore zones. Further, space pictures are being analyzed for the purpose of finding sections with structures analogous to those of known ore objects. Data from the interpretation of space photographs, in combination with information on rock age and composition, manifestations of useful minerals and geochemical and geophysical anomalies are being processed by computers. This makes it possible to mark the most promising areas for detailed work.

On-site confirmation of data obtained by interpreting space photographs has been done in many regions and has already yielded actual practical results. Cosmogeological predictions have been confirmed by the first geological discoveries: we have found ancient volcanotectonic structures that control the location of rare and noble metals in the Far East, zones rich in copper in the area of the BAM, and promising tin manifestations in Yakutiya. The possibility of the effective utilization of space photographs to search for new deposits on the Siberian platform has been developed. As it turned out, many of them are confined to lengthy systems of fractures that are extremely difficult to follow in standard aerial photographs and by ground investigation. Such zones stand out very clearly in space photographs. Prospecting zones were localized by this method and within their boundaries there was a careful interpretation of materials from multispectral space surveys that involved the use of modern equipment. This made it possible to distinguish specific photographic anomalies that were then overflowed by helicopters carrying aerial geophysical stations. An analysis of the geological and geophysical materials that were obtained made it possible to determine sites for the effective location of underground workings and boreholes. As a result, several dozen interesting objects have already been discovered.

There are instances where manifestations of several useful minerals cause changes in topography that are expressed as anomalies in space photographs. From this it follows that direct prospecting methods can be planned. Of course, the detection and--even more--exploration of a deposit with the help of only a few means of space technology is an unrealistic problem at the present time. However, the use of space methods accelerates the process of discovering new deposits of useful minerals considerably because of the detection of previously unknown structural regularities in the location of mineralization. This enables us to improve the reliability of scientific geological predictions and make a more substantiated choice of promising areas for purposeful, large-scale geological surveying work and prospecting. In this branch we have conducted experiments in order to make a quantitative evaluation of the possible effectiveness of cosmogeological cartography. Calculations showed that the expected annual economic effect from the utilization of the results of this type of work, just in the planning of regional geological studies of this country's territory, is 36 million rubles.

The introduction of space information into geological surveying work and the obtaining of specific practical results is based on a system of specialized subdivisions. Aerospace groups have been organized in the regional geological associations. The "Aerogeologiya" association is performing the functions of the leading organization in the development and improvement of remote sensing methods.

A great deal of attention is also being paid to the development of remote methods for studying natural resources in foreign countries. In connection with this, according to the estimates of foreign specialists, up to about 70 percent of the information about the Earth's natural resources that is being obtained from space is being used in the interests of geology.

Recently, new and promising directions for geological investigations and prospecting for useful minerals with the help of space technology facilities have been mentioned: the direct determination of the composition of rocks on the basis of materials gathered by space surveys and flying laboratories; the detection of anomalies in the topography that correspond to increased concentrations of useful components; the determination of the characteristics of geophysical fields in order to study deep structures.

The solution of these important practical problems requires the further improvement of the facilities for obtaining and processing space information. It is necessary to create multispectral, high-resolution scanning systems that utilize a broad band of electromagnetic waves. It is advisable to expand the work being done to study the Earth's physical fields with the help of space facilities. This applies primarily to the Earth's magnetic and gravitational fields, for which special equipment is needed. The huge volume of information being obtained from space makes the further development of systems for the automated processing of remote measurements an urgent matter.

Projects for the creation of new remote sensing facilities to be carried by flying laboratories are being worked on by organizations subordinate to the USSR Ministry of Geology, in collaboration with enterprises belonging to a number of ministries and departments. In recent years we have developed the "Vulkan" a infra-red imager, a multispectral surveying camera, a new side-looking radar system, an airborne spectrometer and other equipment. Tests are being performed on aerospace test ranges in order to determine the geological information content of new materials obtained by remote sensing. Systems have been built for the input of images of the Earth's surfaces into computers, so that they processed automatically, and a complex of algorithms and programs has been developed.

Hero-cosmonauts Anatoliy Berezovoy and Valentin Lebedev worked successfully on board the "Salyut-7" station for 7 months. They performed a large number of experiments in the interests of geology and made observations and photographed the Caspian area, Central Asia, the Ukraine and the BAM region, where geological surveying work was developed on a broad front. Maps with markings from the geological observations made by the "El'brusites" were delivered to Earth. Geologists immediately carried out an operational analysis of them and developed measures for the ground confirmation of the most interesting objects.

These surveys from space, which have already become an ordinary occurrence, are contributing to the further development of space geology, which is a new and important field in the study of mineral resources. Ever more frequently, space photographs are becoming the guiding thread to the riches of the underground warehouses hidden deep in the bowels of the Earth. With a great upsurge of labor, Soviet geologists are realizing the 26th CPSU Congress's instructions on the need for the extensive utilization in geology of the possibilities of high-altitude and space facilities for the study of natural resources.

11746

CSO: 1866/71

UDC (551.24+553.497):629.78

USING SPACE PHOTOGRAPHS TO STUDY TECTONICS AND PREDICT ANTIMONY-MERCURY MINERALIZATION IN SOUTHERN TYAN'-SHAN' MOUNTAINS

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 3 Mar 82) pp 11-18

YABLONSKAYA, N. A., "Aerogeologiya" Geological Production Association, Moscow

[Abstract] The southern Tyan'-Shan' area is one of intensive, high-amplitude, recent tectonic movements where the contrast and ruggedness of the relief are the dominant factors in the shading and image formed in space photographs. These features can be used best to draw up a tectonic map of the region. Three neotectonic elements are most obvious: areas with different types and degrees of ruggedness of relief (blocks differing in the nature and direction of their movement), linear objects (dislocations with breaks in continuity) and ring, half-ring and oval contours (structural lines reflecting the most recent folded formations). After a detailed discussion of the interpretation of space photographs of this region, the author applies the new information to the prediction of mineralization in the Southern Fergana mercury-antimony belt, where the ore fields are confined to horst-anticlines and the ore bodies to the domelike structures in them. Since these structures can be distinguished quite easily in space photographs their use is quite promising. Figures 4; references 14.

[52-11746]

UDC 528.77:551.4+629.78

NEW MORPHOSTRUCTURAL DATA OBTAINED BY INTERPRETING SPACE PHOTOGRAPHS OF BAYKAL-AMUR MAIN LINE REGION

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 8 Dec 81) pp 20-25

VASYUTINA, L. G., and KUSKOV, A. P. (deceased), "Aerogeologiya" All-Union Production Association, Moscow

[Abstract] Information obtained by interpreting space photographs and confirmed by field work at selected locations has been used to compile a new

morphostructural zoning map covering the area from 104° to 141° East Longitude and 58° to 54° North Latitude (on the western edge of the map) or 48° North Latitude (on the eastern edge). The authors differentiate between older and newly developed morphostructural areas, then discuss in some detail the following areas about which new data were obtained:

1) the Baykal rift zone; 2) the Chukchagirskaya area (about 200 miles southeast of Nikolayevsk-na-Amure); 3) the Amuro-Zeyskaya neoplatform area (along the Amur in the Zeya-Bureya interfluve). New information was also obtained about the depressions found in almost all the areas, as well as the ring structures seen in the photographs. Figures 1; references 14.

[52-11746]

UDC (528.77+629.78):550.814

#### BASIC PRINCIPLES OF UTILIZATION OF SPACE PHOTOGRAPHS IN SMALL-SCALE GEOLOGICAL CARTOGRAPHY

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 5 May 82) pp 27-34

STREL'NIKOV, S. I., BORKOVAYA, Ye. A., KOROBOVA, O. R., MALEK, T. I., and PEDOROVA, N. P., All-Union Scientific Research Institute of Geology imeni A. P. Karpinskiy, Leningrad

[Abstract] The authors discuss the utilization of space photographs with different scales in geological cartography, noting that different geological features can be distinguished in the photographs, depending on their scale. They discuss two approaches to the problem: the use of the "dominance principle," in connection with which only those objects interpretable from photographs are shown on maps, and the use of space photographs as just one more source of information. Using two examples (the Pitnyakskaya upland in southwestern Turkmenia and the Klyuchevskaya group of volcanoes on the Kamchatka Peninsula), they point out the utility of space materials in determining various geological features. The authors also discuss a three-stage map compilation process for geological cartography. Figures 3; references 4.

[52-11746]

UDC 528.711.4:53.089.6

CARTOMETRIC ASPECTS OF USE OF SCANNER IMAGES OF EARTH TAKEN FROM SPACE

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 24 Dec 81) pp 35-41

BERLYANT, A. M., and NOVAKOVSKIY, B. A., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] The authors discuss the functioning of a scanner-type space surveying system and the parameters that are involved in it. Then, using materials gathered by the "Fragment" multispectral, high-resolution scanner surveying system, they discuss the various geometric distortions affecting the accuracy of the images obtained and methods for compensating for them, with special emphasis on the preparation of maps of isolines of the total geometric distortions. Figures 5; references 3: 2 Russian, 1 Western.  
[52-11746]

UDC 551.507.362:551.571

SOME CHARACTERISTICS OF FIELD OF INTEGRAL WATER VAPOR CONTENT AND LIQUID-DROP WATER IN ATMOSPHERE OVER OCEAN FROM SATELLITE MEASUREMENTS

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 3 Dec 81) pp 50-56

ALEKSEYEVA, I. A., DOMBKOVSKAYA, Ye. P., TRAPEZNIKOVA, N. B. and MITNIK, L. M., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow; State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] Using materials obtained by "Meteor" artificial earth satellite measurements on wavelengths of 1.35 and 0.8 cm during three periods in 1978 and 1979, the authors attempt to evaluate the fields of integral water-vapor content in the atmosphere and liquid-drop water in clouds and rain for the tropical and northern parts of the eastern Pacific Ocean and the southwest part of the North Atlantic. Using regression relationships calculated for different latitudes and weather conditions, they obtain figures having the following accuracy: for water vapor, 10-15 % for clear weather and a low degree of cloudiness, 30-40 % for heavy cloud cover; for liquid-drop water, 30-50 % or more. Figures 5; references 14: 12 Russian, 2 Western.  
[52-11746]

UDC 551.46+528.7

DETERMINING TEMPERATURE OF EARTH'S SURFACE ACCORDING TO ANGULAR STRUCTURE OF RADIATION IN ATMOSPHERE'S TRANSPARENCY WINDOWS

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 15 Dec 81) pp 69-79

CORODETSKIY, A. K., Institute of Space Research, USSR Academy of Sciences, Moscow

[Abstract] Based on his own previously developed method for determining the temperature of the underlying surface, which was based on extrapolating the angular relationship of the radiation of the surface-atmosphere system to a zero air mass, the author discusses the applicability of this method for various water vapor transmission functions, as well as the use of optimum extrapolation and representation of the radiation's angular relationship with empirical orthogonal vectors. He also describes a spectral-angular method for determining the underlying surface's temperature and reaches the following conclusions: 1) the method is applicable for any of the three water vapor transmission functions he examined; 2) the use of the method of optimal extrapolation results in errors in determining surface radiation temperature on the order of 0.5-1 K; 3) the spectral-angular method can be used for measurements in the 10.4 and 12.0  $\mu\text{m}$  bands. Figures 6; references 16: 9 Russian, 7 Western.

[52-11746]

UDC 528.72(202):535.36

EVALUATION OF NONLINEAR DISTORTIONS OF OPTICAL IMAGE OF EARTH'S SURFACE IN HORIZONTALLY UNIFORM ATMOSPHERE

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 8 Jan 82) pp 80-85

MISHIN, I. V., State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] The author attempts to evaluate the contribution of nonlinear amplitudinal and phase radiation distortions of an optical image of the Earth's surface that are caused by rereflection of radiation on the boundary between the scattering medium (the atmosphere) and the underlying surface. Assuming the probability of photon survival to be constant, he finds that variations in the albedo of the Earth's surface have the greatest effect on these distortions, but that in most cases they account for only 1 % of the total brightness, so that the use of a linear model for the practical evaluation of distortions is justified. Figures 2; references 7.

[52-11746]

UDC 528.7:629.78

METHODS OF RECOVERING SPECTRAL DENSITY OF ENERGY BRIGHTNESS OF NATURAL OBJECTS, USING INTEGRAL MEASUREMENTS

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 17 May 82) pp 95-103

GOGOKHIYA, V. V., State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] In view of the difficulties involved in analyzing and comparing data on integral brightnesses obtained with instruments having different numbers of channels and different spectral resolution qualities, the author presents several methods for minimizing the error in recovering the spectral density of the energy brightness of objects. He discusses instruments with high spectral resolution, the recovery of optical characteristics from the results of measurements, and the recovery of spectral characteristics from the results of measurements with spectral instruments having a small number of wide-band channels. He concludes by saying that in order to use these methods it is not sufficient to know only the instrument's spectral resolution, but that the various channels' exact equipment functions must also be known. Figures 1; references 5: 4 Russian, 1 Western.

[52-11746]

UDC 681.3+528.72

SELECTING INFORMATIVE FEATURES WHEN CLASSIFYING MULTISPECTRAL IMAGES

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 10 Mar 82) pp 104-107

CHIZHEVSKIY, A. M., Specialized Department for Research and Investigation, All-Union "Soyuzgiprovodkhoz" Institute, Moscow

[Abstract] The author proposes an approach to the selection of informative features when classifying multispectral images that utilizes the average probability of correct identification as the criterion for selecting and ranking the features. He sets up the mathematical apparatus, then summarizes it by saying that the procedure consists of selecting the most informative feature first, then selecting a second feature that, in combination with the first, gives the best results and so on. As an example, the computations for 4 spectral bands and 10 classes take 2 minutes for a 5 % confidence interval and a 95 % confidence probability. References 3.

[52-11746]

UDC (528.77+629.78):550.814

POSSIBILITY OF DETERMINING NATURE OF POSTSEDIMENTATION CHANGES IN ROCKS  
FROM SPACE PHOTOGRAPHIC IMAGES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 1 Jun 82) pp 108-110

MASLENNIKOV, V. V., LYUBTSOVA, G. M. and YAPASKURT, O. V., "Aerogeologiya"  
Geological Production Association, Moscow; Geology Department, Moscow State  
University imeni M. V. Lomonosov

[Abstract] The authors use low- and medium-resolution space photographs  
of the Yana-Omoloy interfluve and the results of laboratory tests of soils  
and rocks from different areas within that region in an attempt to determine  
whether or not such photographs can be used to detect postsedimentation  
changes in terrigenous rocks. After giving the results of the tests and  
comparing them with the tones in the photographs, they conclude that  
differences that are not noticeable to the eye, but can only be detected  
under laboratory conditions, do show up in space photographs. Figures 1;  
references 3.

[52-11746]

UDC 535.343+535.247.4

STUDY OF RELATIONSHIP OF SEASONAL DYNAMICS OF SPECTRAL BRIGHTNESS OF SEVERAL  
TYPES OF WHEAT AND PHYSIOLOGICAL PARAMETERS OF PLANTS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 21 Dec 81) pp 58-62

SID'KO, A. F., MOISEYEVA, N. P., SOKOLOV, V. I., FILIMONOV, V. S. and  
SID'KO, F. Ya., Institute of Biophysics, Siberian Department, USSR Academy  
of Sciences, Krasnoyarsk; Krasnoyarsk Agricultural Institute

[Abstract] Using field differential spectrophotometer measurements of the  
spectral brightness of three types of wheat in the period from June to  
August, the authors attempt to find relationships between spectrophotometric  
characteristics and the physiological state of plants and biological productivity  
(crop yield). In their study they take into consideration such factors as  
chlorophyll content, biomass, plant density and leaf area. They conclude  
that spectrophotometric features can contribute to assessments of plant con-  
dition and productivity. Figures 6; references 10.  
[52-11746]

UDC 551.508.25

DIFFERENTIAL SPECTROPHOTOMETER FOR REMOTE MEASUREMENT OF PLANT COVER PARAMETERS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 82  
(manuscript received 15 May 81) pp 111-113

RADAYEV, Yu. P.

[Abstract] The author describes a differential spectrophotometer that determines the difference between the coefficients of spectral brightness of plant cover in the red (660 nm) and infrared (780 nm) bands of the spectrum. The instrument is intended to be installed in an airplane and consists of two identical spectrophotometric channels, photoelements that are switched by calibrating resistors and a normal channel. It also has a compensation channel and keys that enable the channels to be connected in different combinations. Figures 1; references 7: 5 Russian, 2 Western.  
[52-11746]

UDC: 911.52+528.77

USE OF SPACE PHOTOGRAPHS IN AGRICULTURAL TERRAIN STUDIES

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian No 2, Mar-Apr 83 (manuscript received 27 Sep 82) pp 44-50

IVASHUTINA, L. I., KOPYL, I. V. and NIKOLAYEV, V. A.

[Abstract] Space photographs provide regional pictures of agricultural and natural areas, allowing both mapping and regionalization. Repeated space photographs permit studies of agricultural areas during the course of a season or over a number of years. Land reclamation measures are particularly seen in space photographs. These photographs provide valuable information for determination of the type and degree of degradation of land which agriculture may cause. Space photographs thus represent valuable initial material for regional agricultural landscape studies of various types.  
References 7: (Russian).  
[140-6508]

UDC 551.24: 629.78

FEASIBILITY OF USING SPACE PHOTOGRAPHY TO STUDY DYNAMICS OF TECTONIC PROCESSES  
(USING EXAMPLE OF TURAN PLATE)

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 3 Mar 82) pp 5-13

BURLESHIN, M. I., All-Union Scientific Research Institute of Hydrogeology and  
Engineering Geology, Moscow

[Abstract] Using the example of the Turan plate, the feasibility is considered of using space photography to study the dynamic features of tectonic processes forming tectonic structures in their latest stage of development. Two kinds of tectonic movement are distinguished: those forming zones of increased fracturing and dynamic metamorphism, and those altering the spatial position of rock; these can be used to determine the intensity of tectonic processes in an area. Space photography can also be useful in assessing the stage reached in positive tectonic structures, and it is adequate for recognizing tectonic changes in a given area. Detailed examples are given of the interpretation of space photographs in studies of these three aspects (intensity, stage, changes). It is concluded that the landscape-interpretation method can be used not only to distinguish the contours of tectonic structures but also to resolve complicated questions involving the features of tectonic movement, including assessment of tectonic movements from their effect on substances within natural systems, clarification of the stage in the growth of new structures from the relationship between the magnitude of tectonic emergence and total size of an exogenic denudation or accumulation, and studies of the features of tectonic movement and their effect on the geological formation of a territory at various phases of activation. Figures 3; references: 7 Russian.

[84-9642]

UDC 551.25: 629.78

STRUCTURAL-GEOMORPHOLOGIC INTERPRETATION OF LINEAMENTS REVEALED IN SPACE  
PHOTOGRAPHS OF NORTH EUROPEAN PART OF USSR

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 15 Jun 82) pp 15-23

FEDOROV, A. Ye., "Aerogeologiya" Production Geological Association, Moscow

[Abstract] Photographs on a scale of 1:10,000,000 taken aboard a "Meteor" satellite reveal lineaments with azimuths close to 60, 300, 360, grouped in a hexagonal pattern in the north European part of the USSR. The triangular sections making up the hexagonal lattice have sides varying in length between 200 and 300 kilometers (mean 238 kilometers), forming hexagonal cells some 500 kilometers in diameter. Details of the lattice

pattern are provided. The images obtained from the space photography were subjected to geomorphologic and geophysical analysis in order to establish the reality of the lattice and study its properties. The results show the reality of the elements forming the pattern, and also that this pattern forms part of a single whole in terms of a number of its properties. Details of the analysis are provided. The findings suggest that the structure of the earth's mantle is deltahedral. Figures 6; references 12: 8 Russian, 4 Western.  
[84-9642]

UDC (528.77 + 629.78): 551.25(470.52)

**ANALYSIS OF FAULT DEFORMATIONS AND BLOCK STRUCTURES IN BASHKIR ANTICLINORIUM FROM SPACE PHOTOGRAPHS**

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 2 Apr 82) pp 24-31

LYAKHNITSKIY, Yu. S., and STREL'NIKOV, S. I., All-Union Scientific Research Institute of Geology, Leningrad

[Abstract] A comparative analysis was made of available geological and geophysical materials and space photographs on the scale of 1:1,000,000 in order to study patterns in the fault deformations in the Bashkir anticlinorium and their correlation with the location of minerals. Details of the analysis are provided. The analytical findings showed that all faults in the region lie in one of three main directions, namely north-to-west, north-to-east or north-to-south, with the north-to-east lines largely determining the longitudinal structure of the zone. Statistical processing of findings enables the region to be divided into blocks possessing different geological structures. Space photographs revealed that most of the mineral deposits in the zone are located at points where faults intersect, and it was possible to distinguish the areas most likely to contain deposits of lead, zinc, beriet, magnesite, fluorite, copper and iron. Figures 4; references: 5 Russian.

[84-9642]

UDC 553.38: 629.78(575.3)

RESULTS FROM STUDY OF OIL AND GAS RESOURCES OF TAJIKISTAN USING PICTURES  
TAKEN FROM SPACE

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 13 Jan 82) pp 38-42

ISHANOV, M. Kh., LOZIYEV, V. P., PIL'GUY, Yu. N. and NOVIKOV, V. M.,  
"Priroda" State Scientific Research and Production Center

[Abstract] Attempts to use space photography to reveal oil and gas bearing deposits in Tajikistan are described. Black-and-white photographs taken in the 700-840 nanometer range enable detection of tonal anomalies. A total of 117 such anomalies were found in analysis of space photographs. Of these, 47 were recommended for further study as possible anticlinal analogues promising for oil and gas. The abundance of possible sites prompted the authors to develop new methods for making cartographic images of the data obtained. Three kinds of cartographic document were used for this: the map of the anomalies as shown from space, the landscape-tectonic map and the "oil-and-gas resource" map. The features of these maps and their use in detecting promising oil and gas resources are described. The stages of the study from initial data acquisition through field testing to final interpretation of space photographs are discussed. All work is done in close cooperation with interested production and research organizations. Final results showed that this method can be usefully applied in combination with traditional prospecting methods at various stages of oil-and-gas survey work, and can also be used to search for deep oil and gas deposits.

Figures 2; references: 8 Russian.

[84-9642]

UDC 551.24: 629.78(479.24)

EXPERIENCE IN USE OF SPACE PHOTOGRAPHY TO INTERPRET DEEP STRUCTURE OF  
NORTHWEST AZERBAIJAN

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 26 Apr 82) pp 44-50

ALLAKHVERDIYEV, V. M., YERMOLAYEV, V. N. and TISHCHENKO, M. F., Azerbaijan  
SSR Academy of Sciences "Geofizika" Scientific Center, Baku

[Abstract] Structural-geological examination of space photographs of the territory of northwest Azerbaijan (Bolshoy Kavkaz in the north and Malyy Kavkaz in the south) make it possible to establish the identical nature of lineaments with tectonic fractures in this area and also to make further analysis of available data to assess the structure of the mesozoic base of the Srednekurinskiy depression. The geological features of the area are described in detail, as interpreted from 1:800,000-scale photographs taken by the "Meteor" and "Salyut-4" spacecraft, with consideration of the seismic

data. The lineaments detected from space photographs coincide with areas of local magnetic anomalies; details of these anomalies are given. The importance of the tectonics of the mesozoic base in the area should be taken into consideration during prospecting work in this area, since the major fractures along the margins of the blocks may well be routes for the vertical migration of hydrocarbons. The lineaments revealed in space photographs should be considered when analyzing the structure and tectonic structures for prospecting work in the Bolshoy Kavkaz and Malyy Kavkaz. Figures 1; references: 22 Russian.

[84-9642]

UDC 551.25: 629.78

METHODOLOGICAL QUESTIONS IN ANALYSIS OF LINEAMENTS (FROM INTERPRETATION OF SPACE PHOTOGRAPHS)

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 24 Feb 82) pp 51-56

KU'KUSHKIN, D. A. and YAN, G. Kh., "Aerogeologiya" Production Geological Association, Moscow

[Abstract] Individual lineaments with polygenetic formations should be considered not only from tectonic viewpoints but also from hydrogeological, geomorphological, geobotanical and other considerations. A network of lineaments should also be considered as a complex phenomenon, with its own specific pole of stresses corresponding to the deformation field. Aggregates of lineaments should be regarded as a general field resulting from the mutual effect of fields of different scales, intensities and form at the planetary, supraregional, regional and local level. Since old lineaments can be renewed by new movements, the analytical method for lineament fields should be based on the patterns in the genetic link between systems and fields of lineaments and plicative and disjunctive structures of different orders, primarily through clarification of anomalies in the nature of lineament directions. The lineament field can be successfully analyzed by comparing intensity in lineament systems in perpendicular directions and calculation of deformation. Within the Yenisey-Khatanga regional depression, analysis of lineament fields has revealed zones of deep fractures and blocks forming the base of the depression and activated at various periods in its development. Detection of the fields of optimal values for deformation in lineament fields can serve as a criterion in the search for oil-and-gas bearing structures. Circular anomalies in the deformation of lineament fields are of greatest interest in the search for oil and gas. Figures 2; references: 14 Russian.

[84-9642]

STRUCTURAL INTERPRETATION OF SPACE PHOTOGRAPHS BASED ON COMPARISON OF  
PHOTOGRAPHIC IMAGES AND RELIEF OF EARTH'S SURFACE

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81  
(manuscript received 15 Apr 81) pp 57-60

LASTOCHEIN, A. N., All-Union Scientific Research Institute of Geological  
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[Abstract] Shading, color and pattern distribution on color and black-and-white space photographs reflect all the complexly linked processes involved in formation of the present landscape. In terms of surface relief they are classified into two main categories: relief-forming and relief-controlled. The former include the latest movements in morphology and structure and numerous exogenic processes, and the latter the hydrologic, soil and biological processes that together form the natural water in the atmosphere and the soil and plant cover. The morphologic structures and sculpturing seen on space photographs correspond with the hypsometry and orohydrogeography of the Earth's surface. Boundaries of these elements are seen as horizontal or orohydrographic lines (thalwegs and watersheds). Application of these principles enables both sheet and line anomalies to be detected when data are compared with topographic maps. When anomalies fail to coincide it is an indication of a buried structure. This principle was developed from combined analysis of space photographs and the structural and tectonic maps for the East Siberian platform, the Turan plate and other platform fields. The principle can also be applied in prospecting for minerals, since buried deposits not seen from the Earth's surface create geochemical anomalies and anomalies in the soil and plant cover. Figures 1; references: 1 Russian. [84-9642]

UDC 519.21: 681.327

THEORETICAL ASPECTS OF INTERRELATIONSHIP BETWEEN REMOTE MEASUREMENTS AND  
PARAMETERS FOR STATUS OF NATURAL FORMATIONS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81  
(manuscript received 15 Apr 81) pp 69-77

KUZDEROV, V. V., State Scientific Research Center for the Study of Natural  
Resources, Moscow

[Abstract] The feasibility is considered of using field theory to solve problems involving measurements of the Earth taken from satellites in studies of the Earth's natural resources. The problem of describing relationships between radiation and natural formations on the Earth is stated in mathematical terms, and the relationship between various theoretical aspects is examined. Experimental application of the method in 1981 at the All-Union

Scientific Research Institute of Agricultural Meteorology (Obninsk) is described. Further elaboration of the theoretical aspects of the problem should also include consideration of the vector nature of electromagnetic waves with changes in polarization in repeated scattering, shadowing on the basis of ejection theory, modulation of inhomogeneity in the medium by wind currents, and consideration of nonmonochromatic incident waves. Figures 4; references: 19 Russian.

[84-9642]

UDC 525.7: 629.78

#### MODEL FOR CALCULATING CONTRAST IN BRIGHTNESS FIELD IN HOMOGENEOUS OBJECTS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 29 Jul 82) pp 78-83

ZHUKOV, B. S., USSR Academy of Sciences Institute of Space Research, Moscow

[Abstract] An attempt is made to build the simplest possible model for evaluating sensitivity in a brightness field to purely geometric factors (slope and shadowing on surface elements). The measure of sensitivity selected is contrast, which characterizes the magnitude of variation in brightness resulting from differences in slopes and shadowing on surface objects. The effect of geometric factors is assumed to be constant at any given spatial resolution in the photographic equipment. It is further assumed that reflection from surface elements is diffuse, and for this reason bodies of water are excluded from consideration. A description of the model is given in mathematical terms; its main terms describe angle of incidence of sunlight falling on the object, the zenith angle for the Sun, Sun azimuth, solar radiation falling on the Earth's surface, illuminance on the horizontal surface from scattered solar light, and total illuminance of the horizontal surface. Findings from use of the model show that contrast grows as a function of increasing slope angle, shadowing and surface brightness. The greatest contrast is seen in the red and infrared ranges when the Sun is at 40-75° zenith. Figures 4; references: 7 Russian.

[84-9642]

## OPTIMIZATION OF SPECTRAL SENSITIVITY IN PHOTOGRAPHIC SYSTEMS IN REMOTE EARTH STUDIES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
 (manuscript received 11 Mar 81) pp 88-97

GAVIN, G. A., "Priroda" State Scientific Research and Production Center

[Abstract] A methodological approach is suggested to optimization of spectral sensitivity in the channels of photographic survey equipment, taking into account not only the spectral brightness of the object being photographed, but also the actual spectral and energy characteristics of the system used, including aperture ratio and spectral transmission of the objective, magnitude of maximum exposure and so forth. Other factors considered in the approach include darkening density, criterion for light sensitivity and contrast in film, exposure, number of wavelength intervals, spectral distribution of film illuminance, channel sensitivity and width of wavelength interval. It is shown that in all cases optimization is achieved by having discrete zones of maximum sensitivity of optimal width in each channel. This approach is also successful in other remote systems used to study natural resources, including television systems with electronic and mechanical scanning, infrared radiometers and others. Figures 5; references: 8 Russian.

[54-9642]

## METHOD AND DEVICE FOR COMPRESSING SPECTROMETRY DATA

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
 (manuscript received 2 Apr 81, after revision 26 May 82) pp 93-98

KRIMAN, E. I. and GEVORKOV, L. G.

[Abstract] An algorithm for compressing spectrometry data transmitted from aboard space vehicles is described. The algorithm can be used for any kind of scanning device and takes account of output channels required for various kinds of signals (mass spectral, scanning, service) and analyzes data compression achieved by selecting particular data components and discarding others; these include mass peaks and half-widths, scanning-sweep voltages, corresponding to mass peaks, and service values that remain unchanged during scanning. A description is given of satellite equipment developed at the Azerbaijan SSR Academy of Sciences Institute of Space Research of Natural Resources to process mass spectrometry data using the algorithm. A block diagram of the equipment is shown and its operation is outlined. An evaluation is made of the efficiency of the algorithm and equipment and the results of modeling are shown. It is concluded that the proposed method for compressing spectrometric data is efficient and makes it possible to

reduce the number of communications channels by a factor of 18-25 with discrete input signals, thus providing an opportunity for increasing the number of mass spectrometers serviced. Figures 2; references: 4 Russian. [84-9642]

UDC 502.3: 629.78

NONLINEAR FILTERING OF NOISY IMAGES BASED ON MARKOV PROBABILITY MODEL

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 83  
(manuscript received 24 Feb 82) pp 99-106

BEZRUK, A. A. and LEBEDEV, D. S., USSR Academy of Sciences Institute of Information Transmission Problems, Moscow

[Abstract] Inadequacies in filtering algorithms used for image enhancement prompted the authors to investigate the usefulness of the statistical approach to this problem. The first Markov model was used; model parameters were selected from the properties of real images. The filtering procedure was reduced to an iterative procedure for solving systems of nonlinear equations obtained from the conditions required for the extremum for an a posteriori probability. The statistical formulation of the filtering problem and the Markov probability model are examined and the iterative filtering algorithm described. The algorithm was tested on an "Eklips S-330" minicomputer using PL/1 and the results showed that, compared with linear filtering, nonlinear filtering not only improves the visual qualities of the filtered image but also reduces its "distance" from the original. It is therefore concluded that the first Markov probability model with potentials  $W_1(\dots)$ ,  $W_2(\dots)$  corresponds better to the properties of the actual image than does the Gaussian-Markov model with quadratic potentials. Figures 2; references 6: 4 Russian, 2 Western.

[84-9642]

## SPACE POLICY AND ADMINISTRATION

### JURIST COMMENTS ON LEGAL QUESTIONS REGARDING U.S. SHUTTLE

Moscow AVIATSIIA I KOSMONAVTIKA in Russian No 3, Mar 83 pp 36-37

[Article by A. Rudev, candidate of juridical sciences: "Problems of Modern Times: The Space Shuttle and Law of Outer Space"]

[Text] Journal readers ask in numerous letters coming to the editors: Don't Pentagon plans to use space shuttles for military purposes contradict fundamental principles of international law of outer space? This article serves as an answer to this question.

U.S. ruling circles view space as one of the theaters of military operations. They are giving increased attention to implementing the space shuttle program, which from the very beginning was subordinated to Pentagon interests. The shuttle craft which have been created are viewed as a kind of general-purpose catalyst called upon to accelerate the attainment of U.S. military-strategic supremacy in space. The Pentagon intends to use them for reconnaissance, for inspecting space objects, testing equipment of military earth satellites and new kinds and systems of weapons, as a command post, and so on. The possibility of converting them into space bombers--platforms for nuclear or other weapons--also is not precluded. As reported by the foreign press, the United States presently is conducting intensive development of a space-based laser weapon, with plans also for demonstrating its capabilities from aboard the space shuttle.

Practical implementation of such plans by the American militarists unquestionably will lead to a spread of the arms race to outer space and will create a serious threat to peace and the security of states. Even today, however, as shown by flights of the first shuttle craft, they are touching on many vitally important interests of nations and in this regard the problem of international legal regulation of the use of such space objects acquires exceptionally great importance.

Applicable to relationships arising among states in the process of using any kind of space objects, including the space shuttle, are the fundamental principles of international law, including the UN Charter, which are in effect regardless of the sphere or kind of activity, technical means being used and

other factors; as well as the basic provisions of international law of outer space fixed in the 1967 Treaty on Outer Space\* and receiving further development and specification in other international documents on space law.

The treaty on outer space, which secured the obligations of participating states to explore and use outer space for peaceful purposes, fully prohibits militarization of the Moon and other celestial bodies (Article IV). This does not, however, mean that outer space is fully protected against the placement of weapons therein. Only the introduction of nuclear and other kinds of mass destruction weapons into orbit around the earth has been banned. This ban does not extend, however, to all other kinds, including beam weapons. The flight through space of intercontinental ballistic missiles and other suborbital objects with weapons of any kind is not prohibited inasmuch as they do not fall under the definition of a "space object."

As evidenced by the press, the space shuttle's technical capabilities allow it to invade the air space of other states. At the present time a stipulated boundary between air and outer space has not yet been established and so this question now arises with all acuteness.

According to foreign press reports the United States is planning to use the maneuver capabilities of space shuttles and space tugs not only for serving its satellites, but also for inspecting the spacecraft of another state. The possibility of their damage, destruction or "removal" from orbit is not precluded. The interpretation by certain western specialists of the right of access or visitation to the space objects of other countries draws attention in this regard. In fact, Article XII mentions the right of visiting space objects, but only when they are on celestial bodies. The legal basis for access to such objects has to be permission granted by the state of registration for right of access or visitation. Article VIII clearly states that spacecraft are under the jurisdiction and control of the state of registration regardless of whether or not they are functioning or already have fulfilled their purpose.

As shown by the first flights of the space shuttle, an urgent resolution is needed of the problem of preventing harmful effects on the environment. It turned out, for example, that a sonic boom arises in placing the system into space and returning the orbital stage to earth. It is true that by changing the regimes of launch and return the developers succeeded in reducing somewhat the effects of the shock wave above U.S. territory, but what is it like above other states and ocean waters?

Serious fears also are being expressed concerning harmful effects on the environment of combustion products of the first-stage solid-fuel rocket engines. Large-scale implementation of the space shuttle program may have a negative effect on our planet's climate. With each launch some 300 tons of aluminum oxide powder are dumped into the upper layers of the atmosphere. This facilitates a stepped-up formation of ice crystals in cirrus clouds and leads

\*Treaty on Principles of State Activities for the Study and Use of Outer Space, Including the Moon and Other Celestial Bodies.

to increased reflection of solar rays, which threatens a general change in environmental temperature.

Moreover, if the number of flights goes above a certain number (in the opinion of a special American congressional committee, it is 85 a year), this may initiate a growing and catastrophic exhaustion of the ozone layer, which protects all living things on earth against fierce ultraviolet radiation. Replacement of solid-fuel boosters is necessary, but this question has not been resolved to this day. Some \$1.5 billion is needed for developing new engines, and NASA is only promising to examine their use in application to improved models of the space shuttle system.

The Pentagon plans to use the space shuttle system to carry out a large number of experiments. It is silent about the content of many of them. Just what is said on this score in the Treaty?

According to Article IX, participating states pledge to display special caution in conducting experiments in space which could interfere with the activity of other states or have an unfavorable effect on the earth environment. Despite certain deficiencies (the optional nature and absence of precise statements about the time for holding consultations, their participants, procedures for conducting them, and concrete international legal consequences of such consultations), these provisions are of fundamental significance for preventing potentially harmful consequences from functioning of the space shuttle system.

And so based on features of the launch and return of the space shuttle craft and their planned use for military purposes, one can draw a conclusion as to the need for developing various aspects of their legal status, and above all in the area of assuring security.

The first step in this direction already has been taken. The Soviet draft Treaty on Banning the Placement of Any Kind of Weapons in Outer Space, submitted in August 1981 to the 36th session of the UN General Assembly, contains a number of provisions directly concerning the space shuttle. For example, Article 1 of this document prohibits participating states from placing objects with weapons of any kind into orbit around the earth, setting up such weapons on celestial bodies or locating them in outer space by any other means, including on manned, reusable space craft both of existing types and others which might appear in the future. Article 2 of the draft envisages that participating states will use space objects in strict conformity with international law, including the UN Charter, in the interests of maintaining international peace and security and developing international cooperation and mutual understanding.

The Soviet draft Treaty on Banning the Placement of Any Kind of Weapons in Outer Space was submitted for examination of the Disarmament Committee in Geneva and is a good basis for talks.

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## LAUNCH TABLE

## LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
6 May 83	Cosmos-1459	1,028 km	960 km	104.8 min	83°
6 May 83	Cosmos-1460	369 km	218 km	90.1 min	70.3°
7 May 83	Cosmos-1461	457 km	438 km	93.3 min	65°
17 May 83	Cosmos-1462	318 km	224 km	89.5 min	82.3°
		(Earth-resources satellite; incoming data transmitted to "Priroda" State Research and Production Center)			
19 May 83	Cosmos-1463	1,570 km	307 km	103.5 min	82.9°
24 May 83	Cosmos-1464	1,022 km	985 km	104.9 min	82.9°
26 May 83	Cosmos-1465	551 km	349 km	93.4 min	50.7°
26 May 83	Cosmos-1466	367 km	180 km	89.7 min	64.9°
31 May 83	Cosmos-1467	389 km	209 km	90 min	72.9°
2 Jun 83	Venera-15	(Interplanetary station scheduled to reach Venus in October 1983)			
7 Jun 83	Venera-16	(Interplanetary station scheduled to reach Venus in October 1983)			

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
7 Jun 83	Cosmos-1468	283 km (Carries instruments for earth resources studies; data transmitted to "Priroda" State Research and Production Center)	227 km	89.3 min	82.3°
13 Jun 83	Cosmos-1469	377 km	211 km	90 min	72.8°

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**DATE FILMED**

August 2, 1983